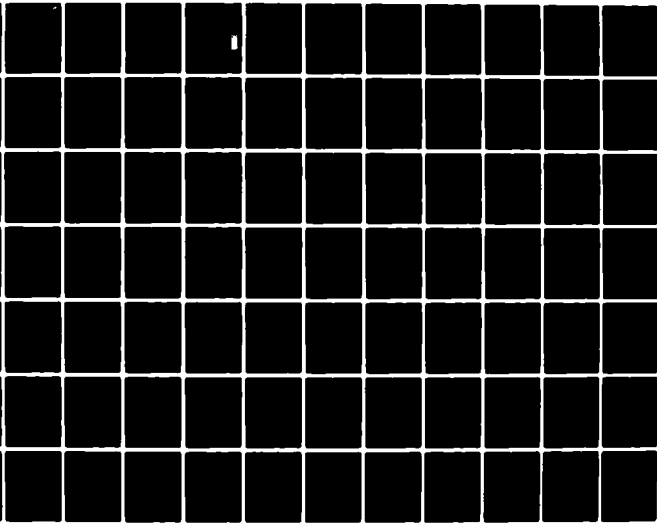
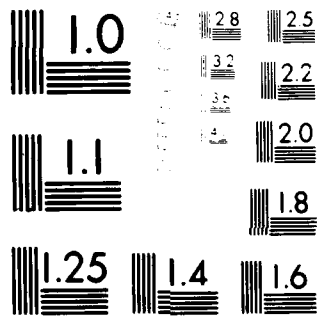


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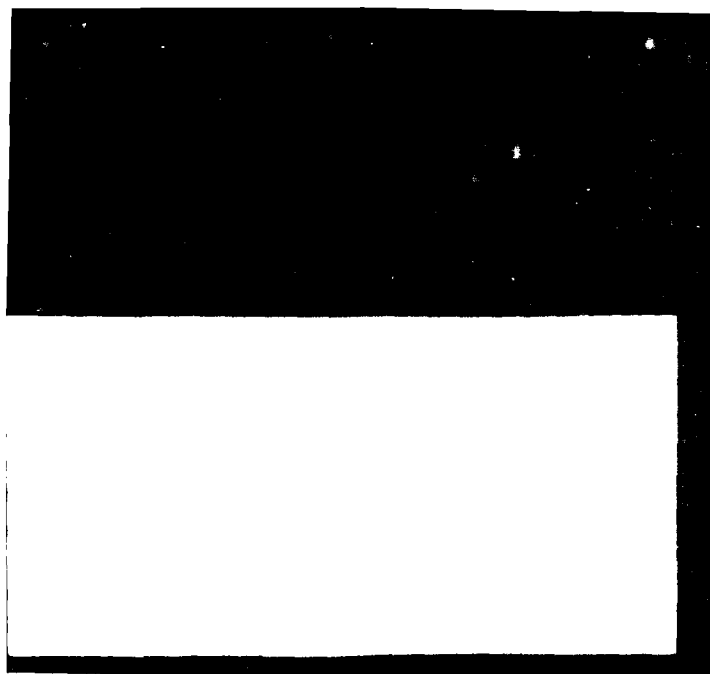
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AN ECONOMIC ANALYSIS OF AIR-CONDITIONING SYSTEMS
WITH OFF-PEAK CHILLED-WATER STORAGE

Bernard J. McMullen, Captain, USAF
Nickolaos D. Papaprokopiou, First Lieutenant, HAF

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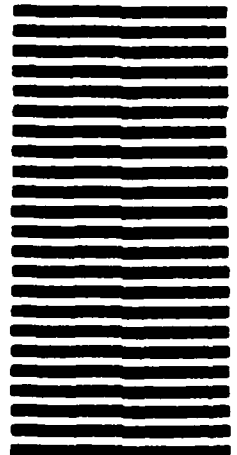
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This thesis investigates current methods of chilled-water storage for air conditioning applications and the economics of chilled-water storage with time-of-use electric utility rates. Current methods of chilled-water storage are investigated by comparing costs of construction materials for storage tanks and effectiveness and costs of anti-blending systems. The economics of chilled-water storage are analyzed by computing total life cycle costs of alternative air conditioning systems for two different sized buildings. Computer simulation is used to determine electric consumption for the buildings. The simulation of each building contains three options: no chilled-water storage, chiller operated only at night, and a small chiller supplemented by stored chilled-water. A gunite or styrofoam tank with a moving partition anti-blending system is the least expensive and most effective storage system. The economics of chilled-water storage are sensitive to the size of the building analyzed. Operating the small chiller with supplemental chilled-water is economical in the smaller building. No chilled-water storage is the most economical option in the larger building. Operation of the chiller only at night was never economical.

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AN ECONOMIC ANALYSIS OF AIR-CONDITIONING SYSTEMS
WITH OFF-PEAK CHILLED-WATER STORAGE

A Thesis

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the
Degree of Master of Science in Engineering Management

By

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1Lt., HAF

September 1981

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This thesis, written by

Captain Bernard J. McMullen

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First Lieutenant Nickolaos D. Papaprokopiou

has been accepted by the undersigned on behalf of the
Faculty of the School of Systems and Logistics in partial
fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN ENGINEERING MANAGEMENT

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CHAPTER I

INTRODUCTION

Background

Energy has become one of the most important issues of the world today. In the past, cheap, abundant energy supplies, particularly electrical energy, have supported the industrial, commercial, and residential needs of the world. However, recent escalation in electrical energy prices, the predicted depletion of oil supplies, and environmental difficulties in using coal as a source of energy for electricity have changed the focus on electrical energy within the utility industry.

Utilities companies have had to change from proponents of the growth of use of electricity to leaders in the conservation of electricity. Historically, in an effort to promote the growth of electricity, large consumers of electricity were billed on a declining block rate structure. The declining block rate structure priced increasing blocks of power consumption at decreasing prices. Now, utility companies are proponents of electrical energy conservation, as indicated by programs such as infrared photography of residences and low interest loans for insulation of customers' homes. The pricing policies for electricity have also been changed to encourage conservation by the large industrial and commercial customers.

On November 9, 1978, President Carter signed into law the Public Utility Regulatory Policies Act (PURPA) of 1978. "The objectives of this Act are: (1) to encourage users to conserve electricity and gas,

(2) to promote the efficient use of facilities and resources (capital and nonrenewable resources) by utilities; and (3) to establish equitable rates for consumers [9:5]." The rate reforms proposed by PURPA are intended to reduce demand, change consumption patterns, and revise the allocation of costs for utilities. Carter administration officials cited the following problems, which they believed rate reforms would alleviate:

Highly uneven expansion in response to anticipated demands for electricity had led to an increase in plant capacity to meet peak demands. This results in under-utilized capacity at other times.

Generating equipment designed specifically for peak loads is relatively inefficient and usually burns scarce, higher priced oil or natural gas. Also, such equipment is operated for only very short periods of time, and capital costs must be amortized over that limited time. As a result, electricity generated during peak hours is more costly than electricity generated during off-peak hours.

Since utility rates are generally not time differentiated, off-peak users are subsidizing on-peak users [9:5-6].

The PURPA of 1978 rejected mandatory changes in electric utility retail rates structures called for by the Carter administration, but includes in Title I of PURPA the premise that rate reforms could help solve some problems confronting the utilities and their consumers (9:6).

PURPA requires state utility commissions to consider adoption of specified rate reforms and changes in associated practices in order to meet one or more of the Act's objectives.

The Public Utility Regulatory Policies Act requires each state regulatory authority to consider at least once, for each utility for which it has ratemaking authority, the following by November 1981:

1. Cost of service pricing: Rates should be designed to reflect the costs of providing service to different customers or classes of customers. For instance, high volume peak-period users might be required to pay a higher rate because their demand increases both

capital and operating costs. In order to ascertain the appropriateness of this standard, the special rules detailed in the Act leave the method to be used for determining cost-of-service to different classes of customers to the discretion of the states. However, the method utilized must permit identification of differences in costs for various classes of customers according to time of day or season. In addition, in prescribing the method to be used, the state authority must take into account the extent to which total cost to an electric utility is likely to change if: (a) additional capacity were added to meet peak demand relative to base demand, and (b) additional kilowatt-hours of electricity were delivered to consumers.

2. Declining block rates: Rate structures which price increasing blocks of power consumption at decreasing rates are commonly known as declining block rates. These rates are to be abolished unless a utility can demonstrate that the cost of providing service to a particular class of customers decreases as consumption increases.

3. Time-of-use rates: Rates which reflect the costs of providing electricity to each class of consumer at different times of the day are to be adopted, unless the practice is not cost effective. "Cost effectiveness" is defined by the legislation to mean that long-run benefits of such rates to the utility and the class of consumers affected are likely to exceed the metering costs and other costs associated with the use of such rates.

4. Seasonal rates: These rates reflected the cost of providing service during different seasons. For instance, in some regions summer is a peak period due to air conditioning requirements.

5. Interruptible rates: These rates are discount rates for consumers who are willing to have their service interrupted during peak hours.

6. Load management techniques: This refers to the use of devices which store electricity during off-peak hours for use during peak hours. Such techniques must be cost effective, as defined by the legislation; that is, (a) they must be likely to reduce maximum kilowatt demand on the utility; and (b) cost-savings must be likely to exceed long-run costs of implementation [25:6-7].

This thesis will deal with the specific case where time-of-use rates have been implemented by a utility company. Before making a statement of the problem which will be addressed, a typical summertime electrical demand pattern will be described, the structure of electrical utility rates and time-of-use rates will be explained, and the progress of implementing time-of-use rate schedules will be discussed.

Electrical Demand Pattern

When attempting to conserve a resource it is important to have a means to identify consumption patterns and measure progress in conservation efforts. An electrical demand graph provides consumption data for electrical energy consumers. An electrical demand graph shows how many kilowatts of electrical energy are being used by an individual or group of utility company customers. The ideal situation for the utility company would be for the graph to be a straight horizontal line depicting a constant demand throughout the day. If such a situation existed the utility company could size its generating capacity exactly to the demand and there would be a reduced need for reserve capacity to meet unexpected or temporary electrical loads. With steady demands, equipment utilization rates would be higher and the economics of electrical generation would be improved (1:1).

Actual electrical demand graphs are characterized by a wavering line with daily peaks and valleys. For example, the electrical demand on the bell substation for McClellan AFB, CA, for the week August 13-19, 1979, is shown in Figure 1. McClellan AFB is an Air Force Logistics Command Base which performs large-scale maintenance on Air Force Aircraft. The graph in Figure 1 shows the peak load occurring in the early afternoon. The peak load is composed of electrical loads from maintenance shops and comfort air conditioning. Days 18 and 19 show weekend loads when the processing shops are not operating but peaks still occur due to air conditioning loads. The interruption in the graph on day 13 was due to a "blackout" at McClellan AFB.

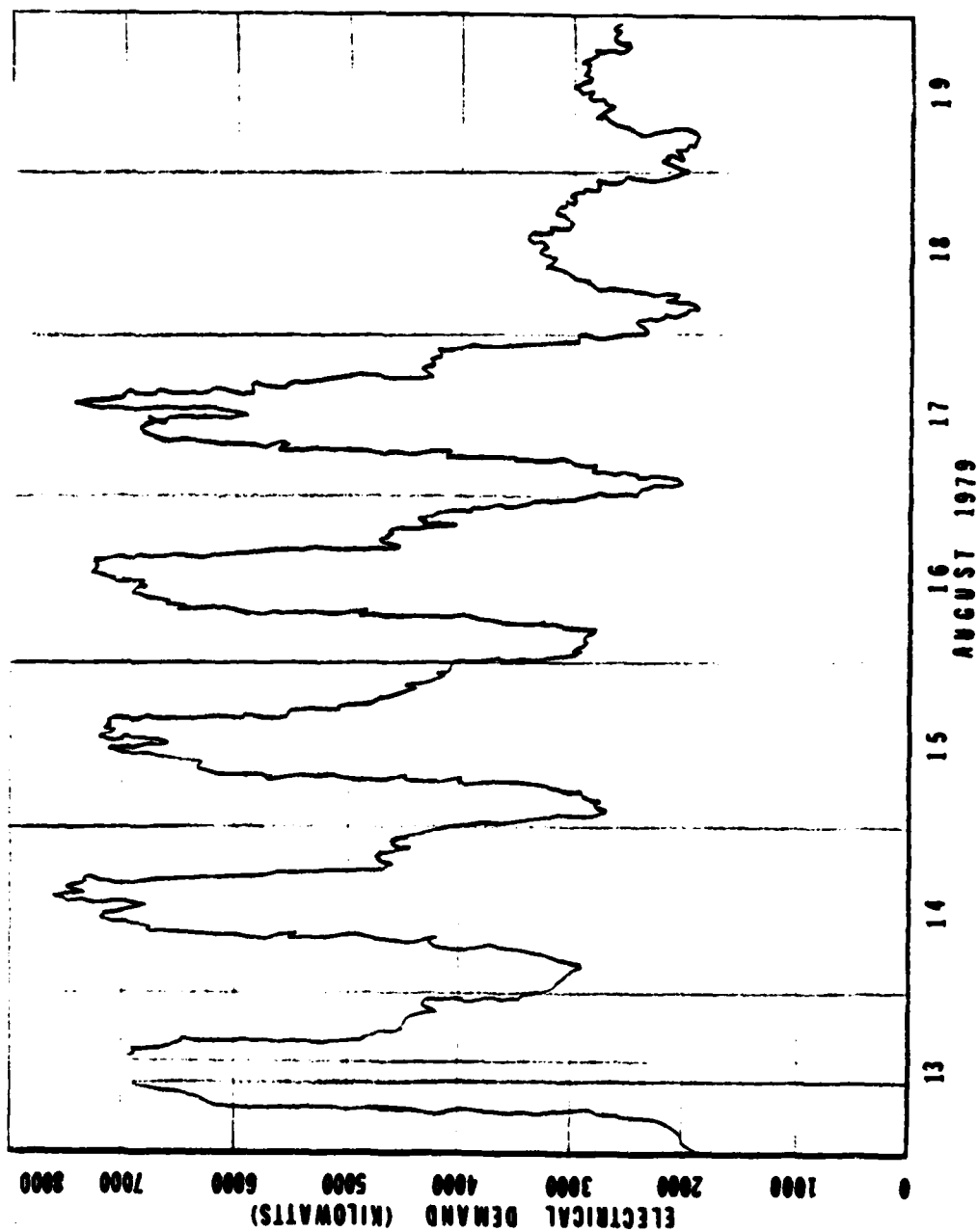


Fig. 1. Bell Substation Electrical Demand Graph (12:5.10).

Utility Rate Structure

The amount of electricity consumed and size of daily peaks recorded by a utility company and depicted on the electrical demand graph determine a customer's electric bill. An electric bill for a commercial or industrial customer is composed of demand and energy charges. Demand charge is the portion of the electric bill based on a customer's billing demand and is expressed as cost per kilowatt (kw). Billing demand is the maximum measured peak demand during a specified period of a month, or if the utility rate schedule includes a "ratchet clause," a percentage of the maximum billing demand established during any of the consecutive eleven preceding months(25:8). The demand portion of the electric bill is determined by multiplying the demand charge by billing demand. For instance, Company A's utility rate schedule states billing demand will be either the maximum 30-minute measured peak demand during the month or 50 percent of the billing demand established during the previous eleven months, whichever is greater. For example, the January 1981 electric bill for Company A contains the following:

Demand Charge

\$3.70

Maximum 30-minute demand

3000 kw

Company A had a 30-minute demand during August 1980 of 7000 kw,

therefore:

$$\begin{aligned}\text{Demand Charge} &= 3.70 \times (\text{max of } 3000 \text{ or } .50(7000)) \\ &= 3.70 \times 3500 \\ &= \$12,950.\end{aligned}$$

Energy charge is the portion of the customer's electric bill based on electricity consumed, measured in kilowatt hours (kwh). The utility company determines the energy cost by taking a monthly meter reading and multiplying the reading by the energy charge. The demand charge and energy charge are combined to arrive at a customer's total electric bill (25:2-8). For instance, Company A's January 1981 electric bill contains the following:

Energy Charge

\$0.04

Kilowatt-Hours consumed

600,000 kwh

Energy Charge = 0.04 X 600,000

= \$24,000

Total Electric Bill = Demand Charge + Energy Charge

= \$12,950 + \$24,000

= \$36,950

Time-of-use rate schedules differ from typical utility rate schedules in the determination of the energy charge. Under a time-of-use rate schedule, a day is broken up into two periods, on-peak and off-peak. The on-peak period is the time of day with relatively high electrical demands, as specified by the utility supplier, typically mid-morning to early evening. The off-peak period is the time of day with relatively low electrical demands, typically early evening to mid-morning. Energy charges are set for each of the periods with the off-peak rate a small fraction of the on-peak rate. Time-of-use rate schedules require that customers have an additional meter installed to distinguish on-peak from off-peak electrical consumption.

For instance, Company B's January 1981 electric bill contains the following:

Energy Charge

On-Peak (9:00 A.M. to 7:00 P.M.)

\$0.04

Off-Peak (7:00 P.M. to 9:00 A.M.)

\$0.007

Kilowatt-Hours consumed

On-Peak

400,000 kwh

Off-Peak

200,000 kwh

$$\begin{aligned}\text{Energy Charge} &= (0.04 \times 400,000) + (0.007 \times 200,000) \\ &= \$17,400\end{aligned}$$

The typical or standard rate schedule as well as time-of-use rate schedules may incorporate seasonal rates. With seasonal rates different demand and energy charges are set for different periods of the year. Seasonal rates are an attempt to pass on the higher costs implicit in seasonal loads, particularly air conditioning (9:25).

Progress of Implementing Time-of-Use Rates

Ten years ago there would have been little relevance in discussing time-of-use rate structures, but today such a discussion is becoming very relevant. Wisconsin Public Service Commission, in 1974, was the first to order time-of-use rates for large commercial and industrial electricity customers (9:17). Since then, commissions in New York, California, Michigan,

Illinois, and Ohio have made similar moves. The first mandatory implementation program for residential users also occurred in Wisconsin. As of July, 1978, time-of-use rates have been filed, ordered into effect, or placed under consideration in twenty-two states, put into effect on an experimental basis in fourteen states, and put into effect in twenty-four states (9:17-18). Most initial time-of-use rate programs are small, experimental, and voluntary, but Dr. Malko of the Electric Power Research Institute reports that mandated programs continue to be implemented at what appears to be an accelerating rate (1:17).

The progress toward implementing time-of-use rates has been slowed primarily by debate over whether to use marginal cost or accounting cost methodologies to design the rate structures (13:130-131). The October, 1980, issue of Electrical World reports that this debate may be settled by action of the Economic Regulatory Administration (ERA).

In the September 4, 1980 issue of the Federal Register, ERA published a notice of a proposed voluntary guideline for a cost-of-service standard under the Public Utility Regulatory Policies Act of 1978 (PURPA) as it relates to section III (d) (1). In proposing the rule, DOE says, "it is DOE's conclusion that section 115 (a) requires, in effect, that marginal cost be taken into account in the course of considering the cost-of-service standard"[13:130].

Joe Crespo, president of Ebasco Business Consulting Co., adds that the significance of settling the debate over whether to use marginal cost or accounting cost was to get people off dead center and to start looking seriously at time-of-use alternatives. In the October, 1980 issue of Electrical World, Joe Crespo stated that:

He doesn't question for a minute that five-years from now the industry will see wider use and acceptance of time-of-use rates [13:131].

Statement of Problem

Electricity encompasses a significant portion of the energy consumed for USAF installation operations. In fiscal year 1980, electricity accounted for 103.6 trillion BTU or 55.8 percent of installation energy. Cost of electricity for installation operations in fiscal year 1980 was \$331.9 million (2:113-114). The implementation of time-of-use utility rates will provide an opportunity to save millions of these dollars. The problem for Air Force managers will be to determine which processes can be economically shifted to off-peak periods.

One component of installation energy is electricity required for air conditioning. Air conditioning loads occur primarily during summer daylight periods. The problem then becomes meeting daytime (on-peak) electrical air conditioning needs with nighttime (off-peak) electricity. When air conditioning is provided by a water-chiller, the chilled-water may be produced in off-peak periods and stored until needed. Before a decision is made to construct and operate an air conditioning water-storage system, it must first be determined if such a system is economical.

Research Objectives

The objective of this research is, first, to describe current methods for storing chilled-water for air conditioning applications, and second, to determine whether the process of producing chilled-water during off-peak periods to meet comfort air conditioning needs is economical when time-of-use utility rates are in effect.

Research Questions

The approach used to meet the research objectives of this thesis was to develop and answer the following research questions:

1. What are current methods for storing chilled-water for air conditioning applications?
2. Will the financial advantages of off-peak utility rates offset the added capital expenditures incurred by a chilled-water air conditioning system with off-peak storage?

CHAPTER II

METHODOLOGY

Introduction

The purpose of this chapter is to describe the methodology used in answering the research questions proposed in Chapter I.

Data Sources

The method used by the researchers to determine current ways for storing chilled-water for air conditioning applications was to conduct a literature search. Initially, Trane and Carrier Air Conditioning Manuals and the ASHRAE Systems Handbook and product Directory were reviewed. The only reference to chilled-water storage was found in the Trane Air Conditioning Manual, which described a storage tank system manufactured by the Dole Refrigeration Company (23:219-220). A search of scientific and technical magazines published since 1979 provided better results. Articles on chilled-water storage were found in the ASHRAE Journal, Popular Science, Electrical World, Engineering News and Record, and Heating/Piping/Air Conditioning magazines. Finally, two newsletters on chilled-water storage, cost information on various sizes of chillers, and major and minor overhaul costs for the respective chillers, were obtained from a personal interview with a Trane Air Conditioning representative (15).

To determine if the financial advantages of off-peak utility rates would offset the added capital expenditures incurred by a chilled-water air conditioning system with off-peak storage, the researchers conducted a comparative economic study. The comparative study consists of an economic analysis completed on air conditioning systems with and without chilled-water storage. The technique that was used to gather electrical consumption data for the economic analysis is computer simulation.

Simulation is defined as a methodology for conducting experiments using a model of a real system (5:475). The researchers used the Building Loads Analysis and System Thermodynamics (BLAST) program, which is a comprehensive set of subprograms for predicting energy consumption in buildings, as the model (16:III). BLAST is correctly being used by the Air Force to perform building energy audits as part of the Air Force Energy Conservation Investment Program, thus the program was available for use by the researchers. BLAST is provided to Air Force users under contract with Control Data Corporation, Minneapolis, Minnesota.

The real system in the simulation consisted of two buildings in Area B of Wright Patterson AFB, Ohio. The economics of chilled-water storage may be sensitive to building size; therefore, selecting two buildings of different size partially investigated this possibility. Table 1 lists information on the two buildings selected as the real system for the simulation.

TABLE 1
REAL SYSTEM

Building No	Building Area (Square Feet)	Building Category Description	Chiller/Type/Size
20040	21543	Dispensary Occ. Health	Reciprocating Air-Cooled/50 Ton
20050	52298	Aircraft Research Engineering	Reciprocating Air-Cooled/120 Ton

Buildings 20040 and 20050 are similar in construction, occupancy schedule, and internal cooling loads. Building 20040 is a single-story U-shaped building with a partial basement. The size of the basement is approximately fifty percent of the first story floor space. Wall construction is exterior stucco, two layers of concrete blocks, and gypsum board, and windows are single pane glass. Building 20040 is a medical dispensary occupied from 0730 to 1630. Internal cooling loads are composed mainly of office equipment and electrical lighting.

Building 20050 is a two-story T-shaped building with a partial basement. The size of the basement is approximately seventy-five percent of the first story floor space. Wall construction is face brick, concrete block, R-14 fiber-glass insulation, and gypsum board, and windows are double pane glass. Building 20050 consists of administrative offices occupied from 0730 to 1630. Interior cooling loads are composed mainly of office equipment and electrical lighting.

The air conditioning systems in both buildings are single unit reciprocating air-cooled chillers. This type of system is commonly used in meeting air conditioning needs of small to medium sized general purpose buildings in the Air Force. A brief description of air conditioning systems is presented in Chapter III.

The BLAST program contains three major subprograms: the Space Load Predicting Subprogram, the Air Distribution System Simulation Subprogram, and the Central Plant Simulation Subprogram.

1. The Space Load Predicting Subprogram computes hourly space loads in a building or a zone based on user input and weather data.

2. The Air Distribution System Simulation Subprogram uses the computed space loads, weather data, and user inputs describing the building air-handling system to calculate hot weather, steam, gas, chilled water and electric demands.

3. The Central Plant Simulation Subprogram uses the computed space loads, weather data, results of air distribution system simulation, and user input describing the central plant to simulate boilers, chillers, on-site power generating equipment, and solar energy systems, and computes monthly and annual fuel and electrical power consumption [16:1].

Computer input files were created for buildings 20040 and 20050 containing the information needed to run the BLAST simulations. The BLAST input files for Building 20040 and 20050 are contained in Appendix A and B, respectively. The information needed for the input files was obtained from building blueprints, site visits to both buildings, and interviews with the building plant managers.

The Central Plant Simulation Subprogram was created with three options, a base case and two alternatives. The base case represented the chiller operating to meet cooling loads as they occurred. The first alternative represents the chiller operating only during off-peak periods with

sufficient storage capacity to meet the entire next-day cooling load. The second alternative represents a smaller sized chiller operating when cooling loads occur. The chiller is supplemented by chilled water stored by the chiller in off-peak hours.

The economic analysis of the air conditioning options was performed using guidelines in Life-Cycle Costing Manual for the Energy Management Programs. Energy costs for the analysis were determined using the electrical consumption data from the BLAST simulations and a time-of-use electrical rate schedule provided by Dayton Power and Light. Chilled-water storage tank investment costs were based on cost data obtained in the literature review accomplished for Research Question One. Chiller investment and maintenance costs were obtained from the Trane Air Conditioning Company. A comparison of the air conditioning options was made based on the total life cycle cost of each option.

Limitations and Assumptions

An objective of this thesis is to determine whether the process of producing chilled water during off-peak periods for air conditioning applications is economical. The economics were examined by applying time-of-use electrical rates to electric energy consumption data. For this reason, absorption chillers were not examined because they are most often powered by steam (17:58).

The economic analysis does not include periodic maintenance costs on the storage tanks due mainly to a lack of information on such costs.

One of the advantages of producing chilled water in off-peak hours is that air conditioning equipment operating in cooler outside air temperatures operates more efficiently and requires less power (11:64). Commercial air conditioning equipment can be either air-cooled or water-cooled. The simulations were performed on air cooled equipment only; therefore, it was not determined if an efficiency advantage exists in one or the other methods of cooling in lower temperature.

Air conditioning chillers produce chilled water at 45°F, which is pumped to air-handling equipment in the conditioned space where the water absorbs heat. The water returns to the chillers at 55°F. The ability of chilled water to absorb heat from the conditioned space is reduced as the chilled water temperature rises (23:214). Chilled-water storage tanks, therefore, must be able to maintain the chilled water close to the temperature of the water leaving the chiller for the air conditioning systems to operate efficiently. The BLAST program assumes there is no temperature rise in the storage tanks. In Appendix E, calculations were performed to determine the amount of temperature rise in the simulated storage tanks. The chilled-water storage tanks are assumed to be concrete cylindrical tanks with a wall insulation value of R-20. The maximum temperature rise for water entering a storage tank at 44°F and stored for twelve hours was 0.06°F. This is a loss of less than 1 percent of the cooling capacity of the water assuming a 10°F temperature rise.

CHAPTER III

PRINCIPLES OF CHILLED-WATER REFRIGERATION AND CHILLED-WATER STORAGE

Introduction

The purpose of this chapter is to examine the principles of chilled-water refrigeration and describe how chilled-water storage tanks are incorporated into a chilled-water system. The major components of a chiller refrigeration system will be described and the most commonly used types of components compared.

Principles of Chilled-Water Refrigeration

The key feature of an electric powered chiller which distinguishes it from other types of refrigeration is electric chillers circulate a secondary cooling medium to the refrigerated space, rather than circulating conditioned air. The major components of a chiller system are the cooling medium, refrigerant, compressor, condenser, evaporator, and control devices.

Cooling Medium

The cooling medium used in a chiller can be water, a glycol mixture, or brine. The type of cooling medium used is based on the temperature of the chilled liquid required for the specific refrigeration-application. About 90 percent of chillers used in industry provide water-based liquids for central station air conditioning systems; therefore, discussion of chillers will be limited to water type equipment (17:58).

Circulating water as a cooling medium requires less building space for the air conditioning system and is less expensive to operate, compared to circulating conditioned air. Because the specific heat and density of water at standard pressure (1.0 BTU/lb-°F and 62.32 lb/ft³) is greater than air at standard pressure (0.24 BTU/lb-°F and 0.075 lb/ft³), the cross-sectional area required for water distribution pipes is markedly less than that required for air system ductwork to accomplish the same cooling task. Consequently, less building space is needed for the cooling distribution systems (4:4.1). Operating costs of water distribution systems are less because pumping horsepower necessary to circulate water throughout a building is usually significantly less than fan horsepower to circulate air (4:4.4).

Chilled-water is pumped to air handling equipment located in the conditioned airspace. The chilled-water is circulated through cooling coils in the air handler and room air is blown over the coils to extract heat. Typically, chilled-water systems are designed to provide chilled-water at 45°F to the air handlers and for the water to return from air handlers at 55°F (17:58).

Refrigerant

The components of a chiller and flow pattern of liquid refrigerant between the components are shown in Figure 2. The most commonly used refrigerants are Refrigerant-11, Refrigerant-12, and Refrigerant-22, which are fluorinated hydrocarbons derived from hydrocarbons and contain chlorine and fluorine. Refrigerants are noncorrosive, nonflammable, non-toxic, and nonexplosive (25:130). "The science of refrigeration is based

upon the fact that a liquid can be vaporized at any desired temperature by changing the pressure above it [23:128]." Under atmospheric pressure, refrigerant-12 has a boiling temperature of -21°F , and refrigerant-22 has a boiling temperature of -41°F (23:428-429). Increasing pressure on the refrigerant causes it to remain in a liquid state until a higher temperature is reached. In the chiller, refrigerant vapor flows into the compressor and is compressed, increasing the pressure and temperature of the vapor. The hot, high pressure refrigerant vapor enters the condenser where heat is rejected. As the temperature of the pressurized refrigerant drops below its saturation temperature, it condenses. The refrigerant moves through an expansion device where the pressure and temperature are lowered. The refrigerant then enters the evaporator. At the lower pressure, the refrigerant boils, absorbing heat from chilled-water flowing through the evaporator (17:58).

Compressor

Electrical powered water-chillers are classified according to type of compressor used, either reciprocating, centrifugal, or screw. Size of chillers is measured in terms of tons of refrigerant, one ton of refrigeration being the capacity to absorb 12,000 BTU's of heat in one hour. Reciprocating chillers are available in sizes up to 200 tons, screw machines are used between 50 and 750 tons, and centrifugal chillers encompass a broad range between 75 and 5000 tons (17:58).

Reciprocating compressors are positive-displacement machines with crankshaft-powered pistons working in cylinders, equipped with suction and discharge valves much like an automobile internal combustion engine (17:59).

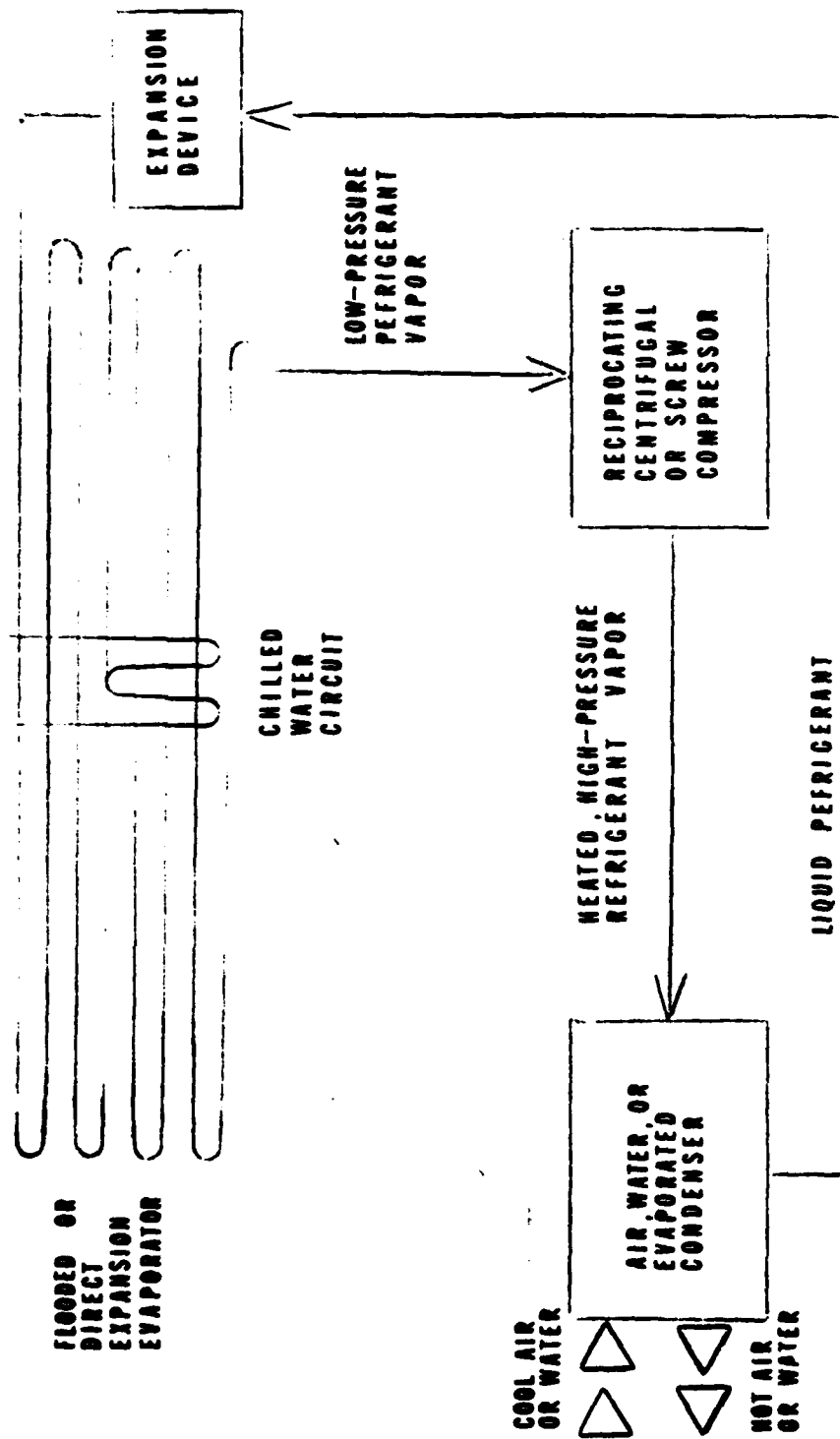


Fig. 2. Components of Chilled-Water System (17:58).

•Centrifugal compressors are variable-volume displacement machines with one or more rotating impellers imparting centrifugal force to compress the refrigerant, similar to the action of a household fan (17:61).

•Screw compressors are positive displacement machines with compression resulting from the meshing action of grooved, precision-machined lobes on male and female rotors (17:61-62).

Building air conditioning loads vary with the time of day and season of the year. Chillers meet this varying load by adjusting the capacity of the compressor rather than functioning in an on-off fashion. Electrically powered chillers would appear to be ideal candidates for on-off operation in a load-shedding environment where an organization is attempting to share peak loads. Although cycling the chiller off for short periods will not result in a significant rise in the conditioned space temperature, there are some drawbacks to this type of operation:

1. Large horsepower motors are designed to handle a certain maximum frequency of starts within a given time period.

2. Once cycled off, the motor must have sufficient time to dissipate built-up heat before it is restarted. Starting current in large motors is typically about 200 percent of operating current and the heat from the starting current in addition to the motor's residual heat will harm the winding insulation, shortening motor life.

3. Large air conditioning systems generally have some type of internal electrical timing control to prevent too-frequent cycling, perhaps enforcing a minimum off-time of 30 minutes (18:16).

The means used to vary the capacity of the compressor depends on the type of equipment. The most common means of capacity control in reciprocating chillers is to unload one or more cylinders, to bypass a proportion of the evaporator vapor within the compressor, or vapor bypassing external to the compressor (3:12.10). Centrifugal chillers adjust compressor capacity through variable inlet guide vanes placed in front of the impeller. Varying the angle of the guide vanes causes pre-rotation of the entering gas and subsequently produces less compression (1:13). Screw compressors incorporate a movable sliding valve. Opening of the valve produces a gap which retards the point at which compression begins (3:12.17).

Condensers

There are three types of condensers commonly used with water-chillers: air-cooled, water-cooled, and evaporative. An air-cooled condenser consists of a coil, casing, fan, and motor. The hot refrigerant vapor passes through the coils and is cooled and condensed by means of ambient air blown over the coils by the fan. Heat is rejected directly to the air by sensible heat transfer (8:55-57).

A water-cooled condenser consists of heat transfer tubes mounted inside a steel cylindrical shell. Hot refrigerant vapor enters the shell and is cooled by water passing through the tubes. The condensed refrigerant then flows to the evaporator. Source of cooling water can be a lake, river, or well, but is most typically exhausted condenser water recycled through a cooling tower. Heat transfer in water cooled condensers is sensible cooling from the water, heat transfer in a cooling tower is sensible and latent cooling by air (8:55-57).

An evaporative condenser consists of a condensing coil, fan and motor, water distribution system, recirculating pump, and casing. Hot refrigerant vapor enters the coils and heat transfer occurs to the water which is diffused over the coil surface. The heat is then transferred to air passing over the coils. Evaporative condensers use a combination of latent and sensible heat transfer (8:60).

The following general statements can be made concerning condensers:

Water-Cooled Condensers

1. Occupy the least amount of space except when a cooling tower is used.
2. Require a cooling tower or an inexpensive source of water.
3. Located indoors, with cooling tower outdoors.
4. Require water treatment when used with cooling tower.
5. Require pump and water piping large enough to handle total water flow.
6. Unit size range from small to very large.
7. High maintenance when cooling tower included.

Air-Cooled Condensers

1. Require no water and, therefore, normally have no problems of freezing, scaling, or corrosion. In industrial atmosphere, corrosion may become a problem.
2. Higher peak power requirement per ton than an evaporative condenser or water-cooled condenser.
3. Lowest installation and maintenance cost.
4. Usually located outdoors.
5. No water piping or pump required.
6. Capacities over 125 tons generally require multiple units.
7. Longer refrigerant lines required.
8. Possible problem if required to operate at low outdoor temperature.
9. Minimum maintenance.

Evaporative Condensers

1. Require much less circulating water than water condenser with cooling tower, therefore, uses a smaller water pump, and water lines of smaller size and shorter runs.

2. Usually require less space than air-cooled condensers, or a water-cooled condenser with cooling tower.
3. May be located indoors.
4. Require water treatment.
5. Large sizes available.
6. Medium maintenance [23:175-176].

Power requirements of a water chiller are a function of the percent of design load, leaving chilled water temperature, and ambient air or cooling-water temperature. While reduction in load produces the greatest reduction in power, significant power savings are possible with reduced ambient air or cooling water temperatures through more efficient condenser operation (17:64). With lower outside air temperatures, air cooled condenser fan speeds can be reduced, or on a multiple fan unit, one or more fans can be shut off while maintaining the rated cooling capacity of the unit (3:16.13). With a water cooled condenser and cooling tower, lower outside air temperatures will lower the temperature of condenser water returning from the cooling tower. The cooler condenser water reduces pressure in the condenser below design conditions and subsequently the compressor has to overcome less head pressure. With less head pressure the compressor consumes less power (11:64). "For example, at 100 percent load, a 10°F reduction in cooling water temperature produces nearly 10 percent reduction in power use [11:64]." Water cooled condensers are designed for an entering water temperature of about 85°F, however, most chillers can be operated satisfactorily at temperatures below 60°F (11:64).

Evaporator

There are two common types of evaporators (also called coolers) used to provide chilled water for air conditioning systems: flooded and direct expansion. The flooded type evaporator consists of an outer shell encasing

a bundle of tubes through which flows the water to be chilled. About half to three-fourths of the tube bundle is immersed in liquid refrigerant, which boils because of the heat received from the water being cooled (23:159). In the direct expansion evaporators, also of the shell-and-tube type, liquid refrigerant boils and evaporates inside the tubes while water is circulated over the tube bundle (23:161). The direct expansion type evaporator has the advantage of a smaller pressure drop in the chilled water circuit and a smaller charge of refrigerant (23:161). "Flooded evaporators are usually installed on centrifugal packages, and direct expansion coolers are normally selected for reciprocating machines; screw chillers use both types [17:63-64]."

Chilled-Water Flow

Chillers are typically designed to deliver chilled-water to air handlers at 45°F and have the water return from the chillers at 55°F under full load conditions. Flow of water through evaporators is recommended to be held constant by manufacturers independent of load on the chiller (24:1). Varying chilled-water flow does not affect operation of air handlers but constant flow is recommended for chillers for the following reasons:

1. Constant water flow aids in reliable heat transfer in the evaporator. Under conditions of low water flow, refrigerant temperatures fall below the freezing point of water and damage may occur from freezing of the evaporator tubes (24:1).

2. Without constant chilled water flow, the return water temperature is not an indicator of load (24:4).

Chilled-Water Storage System

The concepts involved in chilled-water storage are both simple and straightforward. A schematic diagram of a chilled-water storage system is shown in Figure 3. The system consists of a chiller, storage tank, and circulating pumps.

Chilled-water storage systems can be operated in one of two ways. The chiller can be used to charge the storage tank at night during periods of small or no cooling loads and then shut down. Storage tanks are then used to meet cooling loads occurring after the chiller is shut down. In this case, air handlers are equipped with two-way control valves designed to allow a set temperature drop across the air handlers. The chiller operates at design load, filling the storage tank and diverting sufficient chilled-water to meet any cooling loads. The circulating pumps supplying chilled-water to the air handlers are variable volume pumps supplying only enough water to meet the load with a set temperature drop in the chilled water (22:1-2).

The second case involves continuous or near continuous operation of the chiller. The chiller, in this case, is sized smaller than one needed to meet peak cooling loads. The chiller is run at night to fill the storage tank and also meet any occurring cooling loads. As the cooling loads increase, more of the chilled-water is directed to air handlers until the cooling load matches the chiller size. When cooling loads exceed the capacity of the chiller, chilled-water from the storage tank is then pumped

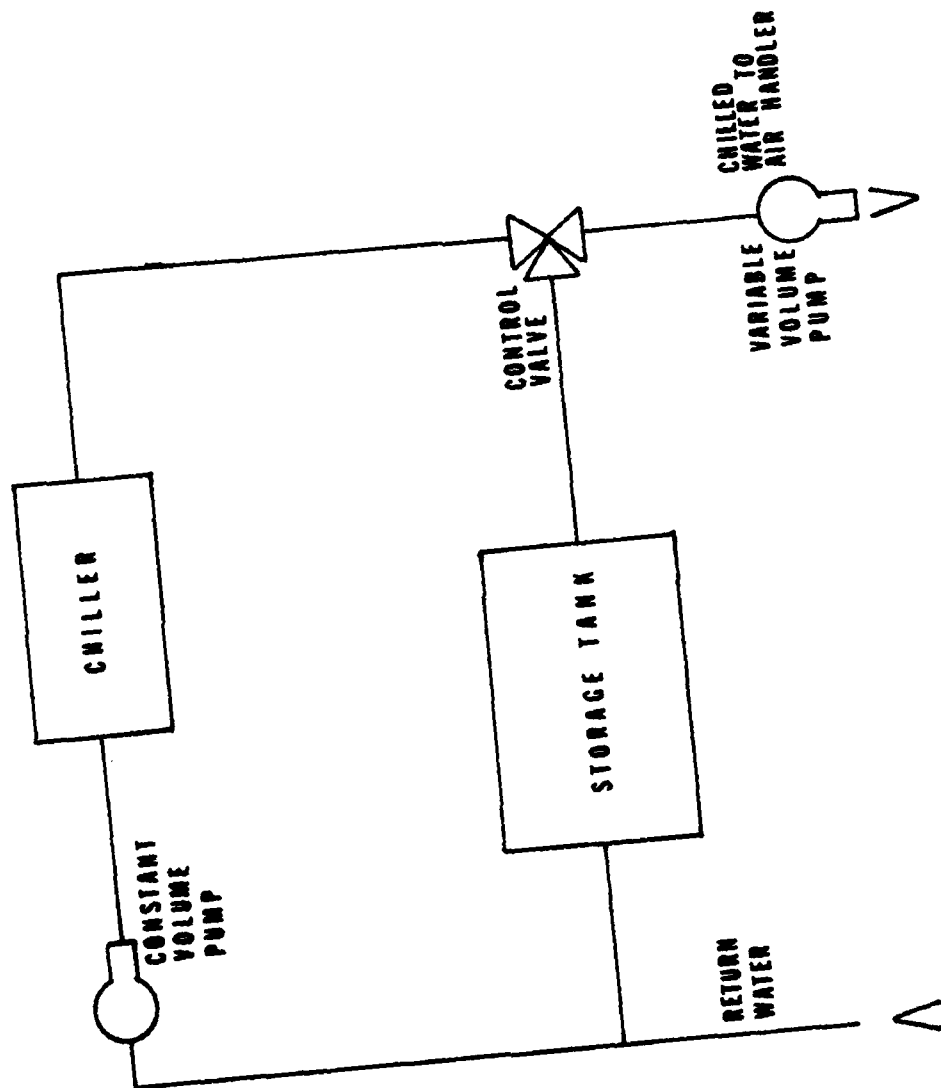


Fig. 3. Chilled-Water Storage System (22:2).

to the air handlers in addition to chilled-water coming from the chiller. In this case, as in the previous case, the circulating pump supplying chilled-water to air handlers are variable pumps supplying only enough water to meet cooling loads with a set temperature drop in the chilled water (22:1-2). Systems can be designed with more than one chiller in the circuit as shown in Figure 4.

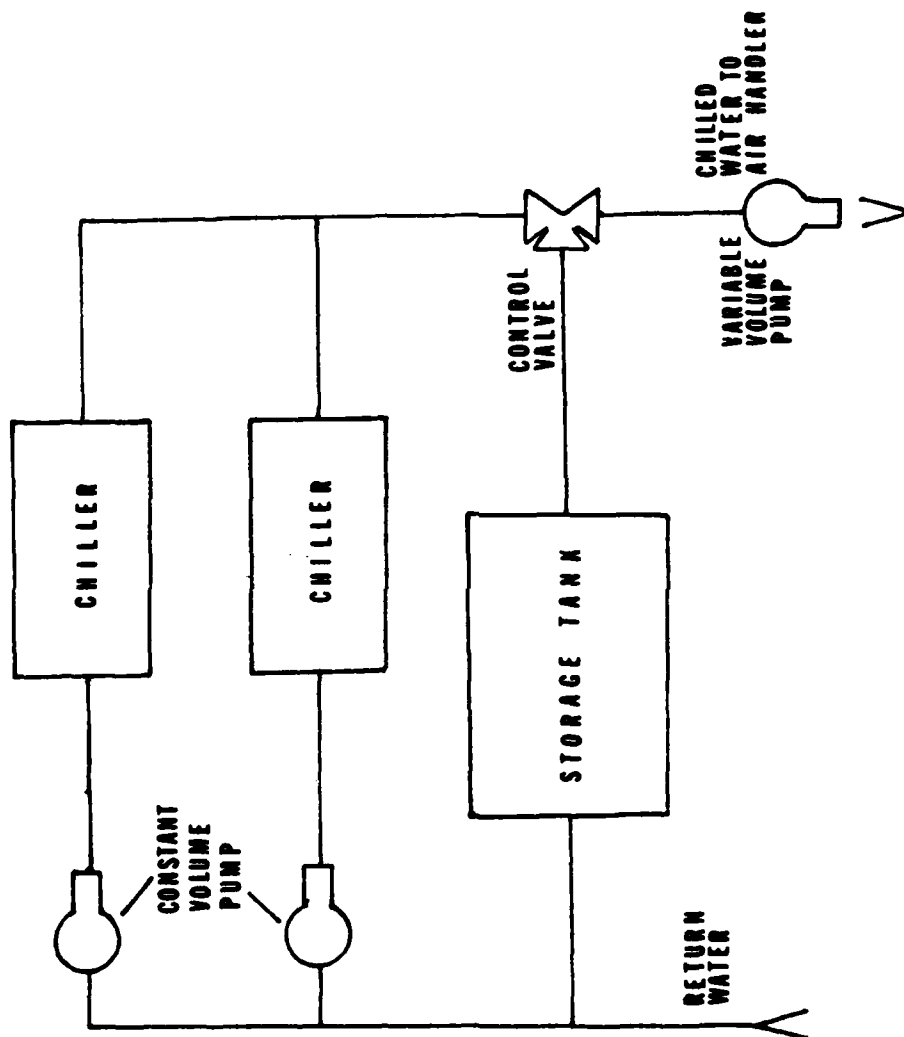


Fig. 4. Chilled-Water Storage System, Multiple Chillers (22:3).

CHAPTER IV

CURRENT CHILLED-WATER STORAGE SYSTEMS AND ECONOMIC ANALYSIS

Current Chilled-Water Storage Systems

The current methods for storing chilled-water for air conditioning applications are examined by considering the materials used in construction of storage tanks and methods used in preventing blending of water within the tanks.

Construction Materials

Chilled-water storage tanks have been constructed of steel, concrete, gunite, and styrofoam. Steel tanks can be prefabricated or constructed on site. The largest steel tank which can be prefabricated off-site is 30,000 gallons and costs are about 50¢/gal (21:69). If the tank must be reinforced to accept the static head of a system, costs escalate to above \$1.00/gal (21:69).

Because of the high cost of steel, it is more practical to use concrete tanks. Tanks in the 100,000 to 500,000 gal category have been installed for as little as 20¢/gal (21:69). Concrete storage tanks can be placed on top of buildings to save on transfer pumping energy. Roof top installations incur a structural penalty of about 4¢/gal plus 1/4¢/gal per story of building height (21:69).

Gunite walls with posttensioning bands to avoid cracks can be used to reduce weight and cost of concrete tanks. "Gunite is a trademark for a concrete mixture sprayed under pressure over steel reinforcements, as in making swimming pools [14:623]." Gunite tanks may be fabricated for as little as 15¢/gal in 50,000 to 100,000 sizes (21:69).

Storage tanks are also being fabricated using four inch thick styrofoam sheets with metal band reinforcement and coated fabric liners. The cost of styrofoam tanks is similar to that for the gunite tanks (21:69).

The material used in the construction of a chilled-water storage tank for any particular installation will depend on such factors as size, difficulty of excavation, and the design practices of the consultant. In any application, the economics of using a particular construction material should be considered.

Anti-Blending Methods

The effective operation of a chilled-water system with storage requires a means of separating the chilled-water from its warmer return water. When warmer return water enters the storage tank, it is useless if it returns to the system before being processed through the chiller. Hot-water storage tanks rely on stratification of water within the tanks to separate the hot and cooler water. This is possible because of the buoyancy characteristic of water in the hot water temperature ranges. But as Figure 5 reveals, the buoyancy characteristic of water over the chilled-water range differ so little that buoyancy is a poor means of preventing blending of water in a chilled-water storage tank (21:65-66).

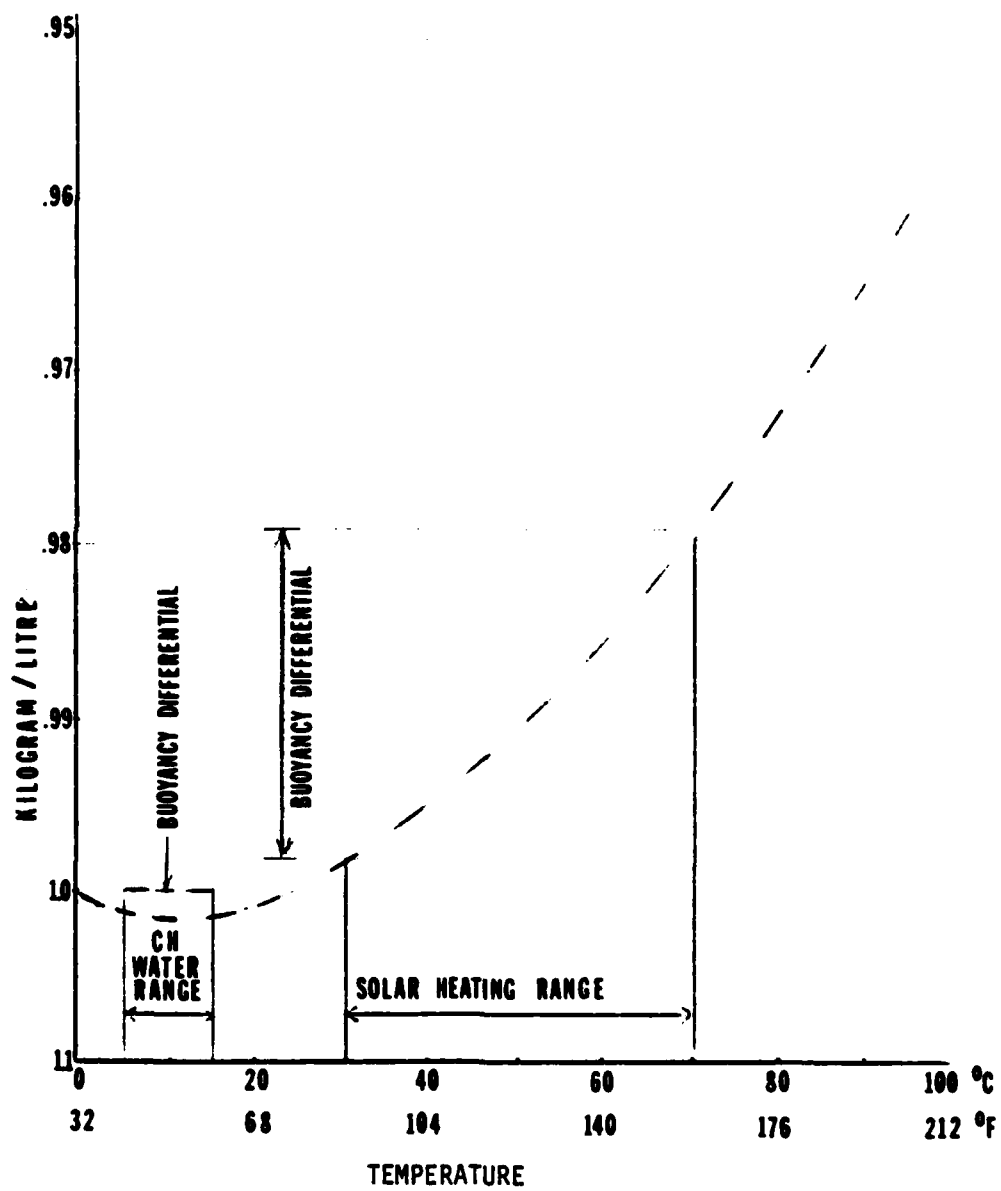


Fig. 5. Water Buoyancy (21:65).

One method of hindering blending in a chiller-water tank is use of fixed baffles. Layout of the tank is shown in Figure 6. The fixed baffles are arranged in the form of weirs (dams) which promote a "piston flow" between the compartments. For instance, chilled-water enters the storage tank in Figure 6 on the right and follows a flow pattern shown by the dotted line. As the chilled-water enters a compartment, an interface is formed between the 45°F water and the 55°F water. The interface moves up the compartment during the filling process; thus the "piston flow". As the interface approaches the top of the compartment, the 45°F water begins to pour over into the next compartment before the preceding compartment is completely empty. The 55°F water remaining in the compartment blends with 45°F water in the shaded area shown in Figure 6. Chilled-water is discharged from the storage tank by reversing the flow pattern through the tank. Tests on a single pass through a fixed baffle system showed about 85 percent of the tank volume remained unblended (21:67). Concern with this concept lies in a tendency for the blended portion to increase with each reversal of flow. Testing has shown the blended volume is variable, depending on rate of flow and the resultant head of water between segments (21:67). The fixed baffle method has been used in Japan where construction of the storage tanks is subsidized by the need for earthquake protection. Japanese buildings use earthquake reinforcement in the form of intersecting shear walls at the basement level. Little modification is needed to form a container for water storage (21:66-67).

A second method of hindering blending is the empty tank concept. With this method, water flow in a compartment only occurs in one direction at any one time. Layout of the tank is shown in Figure 7. In this method there is a tradeoff between cost of partitions in the tanks and cost of the

volume for the spare tank. "Rough cost analysis seems to indicate that the lowest enclosure cost, including the partitions and shell, will result from a tank which contains from six to nine compartments [21:67]."

Automation of the compartment isolation and manifold valves would be essential with an empty tank system. Otherwise, an operator would be required on constant duty to regulate the flow between compartments. The designers of a \$45 million, 21-story building in Los Angeles have halved the size of its air conditioning plant by adding a 640,000 gallon chilled-water storage tank. The storage tank is constructed of reinforced concrete, plastic lined, and is buried beneath the lowest level of a four story underground garage. The empty tank concept is used with the storage tank divided into eight compartments. A computer based control system is used to start and stop the chiller, and to determine how much chilled-water to prepare for the next day (10:17).

A third method of hindering blending is the moving partition concept. A schematic of the moving partition system is shown in Figure 8. The moving partition is constructed of coated fabric and fastened at mid-height. The membrane floats up and down to suit variable proportions of 45°F and 55°F water (21:69). Screens are placed over the in-flow and out-flow area to avoid trapping the membrane. The moving membrane methods requires walls of the storage tank be smooth to reduce rubbing wear of the membrane. A thin stationary plane of 50°F water forms above and below the membrane and acts as insulation against heat transfer (21:69). A two-million square foot office building in Calgary, a western Canadian oil town, was designed with cold and hot-water storage tanks, and no heating plant. The design is based on the fact that office buildings require air

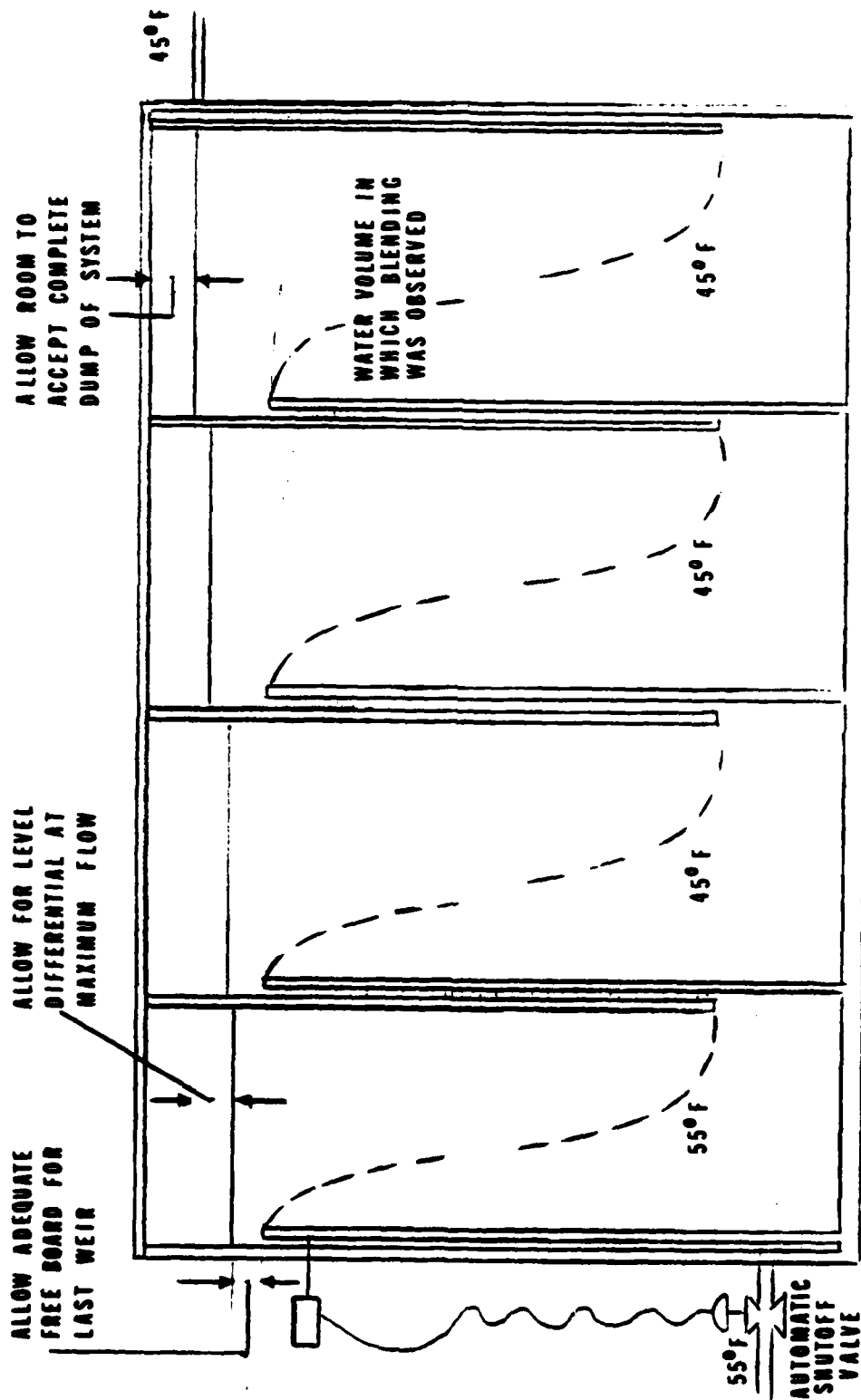


Fig. 6. Fixed Partition System (21:66).

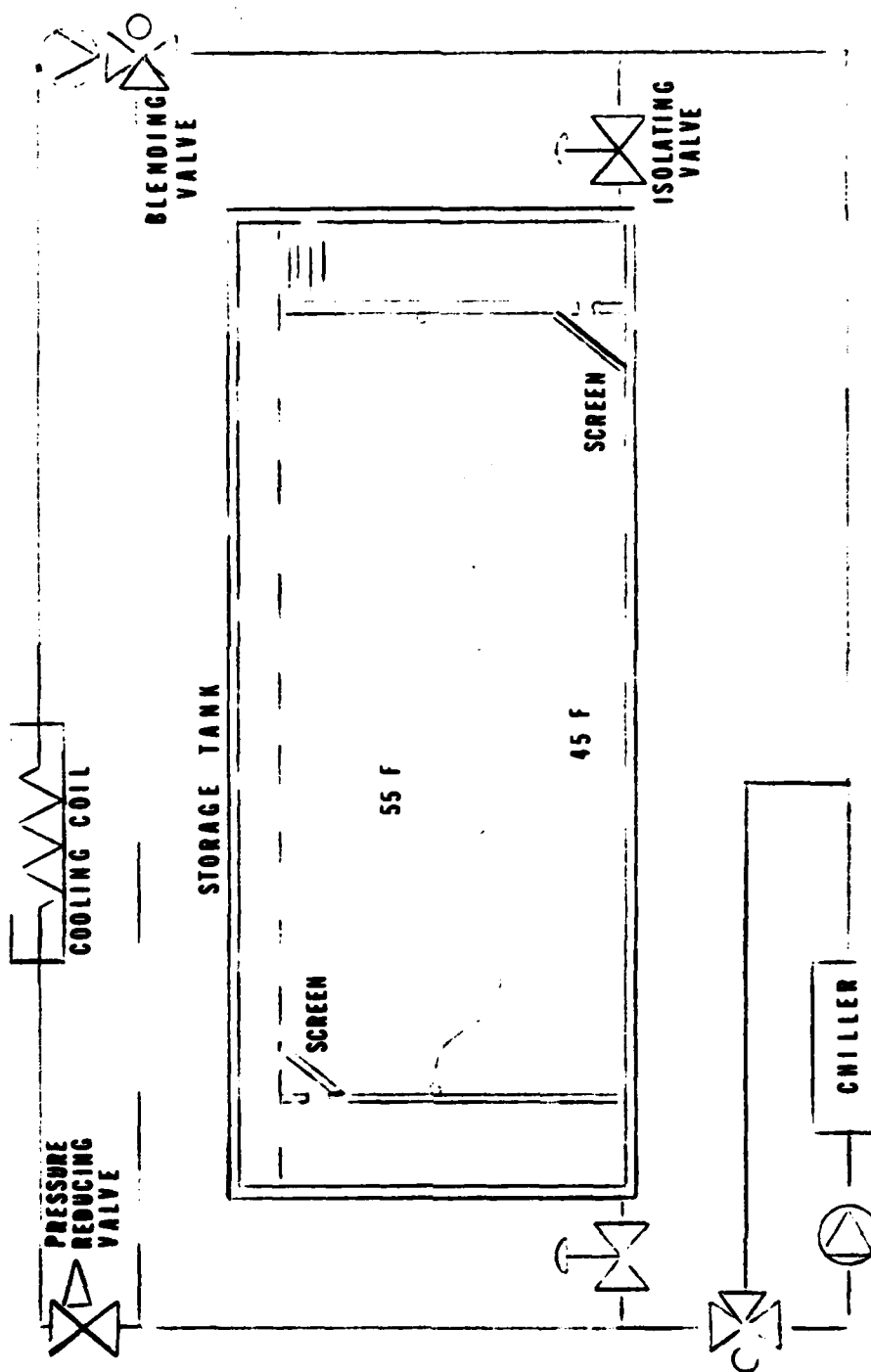


Fig. 8. Moving Baffle System (21:69).

conditioning year round since people, machines, and computers create excess heat within the core of an office building (6:20). Winter heating is obtained from hot-water tanks which recycle discharge heat from the buildings chillers. Chillers operate at night and the chilled-water is stored in two 250,000 gallon tanks. The storage tanks are equipped with a moving membrane system to prevent mixing of incoming and stored water (6:21).

Relative costs of the various anti-blending methods are contained in Table 1. The costs are based on a storage volume of 300,000 gal and water depth of 12 ft (21:70).

Economic Analysis

The economics of a chilled-water air conditioning system with off-peak storage were analyzed by performing a total life-cycle cost (TLCC) analysis on each air conditioning alternative. Guidelines in Life-Cycle Costing Manual for the Federal Energy Management Programs were used for the TLCC analysis.

This manual amplifies the methodology and procedures for life-cycle cost analysis established by the Department of Energy (DoE) in Subpart A of Part 436 of Title 10 of the Code of Federal Regulations (10 CFR Part 436), which is entitled "Federal Energy Management and Planning Programs" (FEMP). It incorporates proposed changes in the methodology and procedures made in response to recent amendments to the law. It is intended as an aid to implementing life-cycle cost evaluations of potential energy conservation and renewable energy investments in existing and new federally owned and leased buildings as required by Section 381 (a) (2) of the Energy Policy and Conservation Act (EPCA), as amended, 42 U.S.C. 6361 (a) (2); by Section 10 of Executive Order 11912, as amended by Executive Order 120003 (Executive Order); and Title V of the National Energy Conservation Policy Act (NECPA), 92 Stat. 3275, as amended by Section 405 of the Energy Security Act, 94 Stat. 611 [19:iii].

TABLE 2

RELATIVE COST FOR VARIOUS ANTI-BLENDING SOLUTIONS (¢/US GALLON)

Item	Type Anti-blending		
	Fixed Baffles	Empty Tank	Moving Baffle
Storage Tank	30	30	30
Basic Piping	4	8	4
Stationary Baffles	8	-	-
Nozzles and Pipe Headers	-	-	-
Empty Tank (1.5 Compartments)	-	8	-
Extra Partitions	-	6	-
Space for Empty Tanks or Oversizing	This may be inconsequential, but where space is at a premium it may be the most significant cost of all.		
Deeper Excavation or NPSH Pump	-	2	-
Moving Baffle	-	-	6
Screens, Wells, Lights, etc.	-	-	6
Control & Instrumentation:			
Basic	3	5	3
Extra Valves and Processor	-	5	-
Extra Tank Volume to Compensate for Blending	10	2	-
TOTAL	55	66	49

SOURCE: ASHRAE Journal, January 1980

The TLCC analysis takes into account costs of different air conditioning equipment, minor and major overhaul costs, storage tank capital costs, utility costs, and salvage and resale costs. Costs of air handler and air distribution equipment are not included since this equipment is common to each alternative. Energy costs are included only for the four months (June-September) summer period. Energy costs for the other months are identical to each alternative and do not affect the comparison of alternatives. Costs occurring in future years are compared to current costs by adjusting future costs for opportunity costs.

Key Elements of the TLCC Analysis on
Buildings 20040 and 20050

The key elements included in the analysis are:

1. Life cycle cost evaluations account for investment costs, nonfuel periodic maintenance costs, and energy costs. Investment costs and nonfuel periodic maintenance costs are summarized in Table 3.
2. Time-of-use energy costs are approximated based on information contained in a Dayton Power and Light Company rate proposed for time-of-use rates. A Facilities Charge of \$0.53 per KW of on-peak or off-peak demand is assessed to the maximum hourly demand recorded during any of the previous twelve months. A Demand Charge of \$5.09 per Kw is assessed for all kilowatts of billing demand per month. An Energy Charge of \$0.0125 per KWH on-peak and \$0.002 per KWH off-peak is assessed for all kilowatt-hours consumed per month.
3. The Uniform Present Worth Formula Modified (UPW*) for DOE region 5, which includes Minnesota, Wisconsin, Michigan, Illinois, Indiana, and Ohio, was used for discounting future costs of energy. Value of UPW* is 11.95 (19:130).

4. The air conditioning equipment is assumed to have a twenty-five year service life with a zero salvage value.

5. All future dollar amounts are estimated in constant mid-1980 dollars. A discount rate of 7 percent is used to adjust costs to mid-1980 dollars.

6. The study period for the alternatives will be twenty-five years.

7. Initial investment costs are reduced to 90 percent of cost to adjust for social benefits of saving nonrenewable energy (19:2).

8. Storage tank investment costs are summarized in Table 4 and are based on a cost of \$0.49 per gallon of storage and determined as follows:

$$\text{I.C.} = \text{Storage size (BTU)} \times \text{Specific Heat of Water}$$

$$\times \frac{1 \text{ gal}}{8.33 \text{ lb of water}} \quad \times \frac{1}{T \text{ of Chilled H}_2\text{O}} \times$$

$$\frac{\$.49}{\text{gal}}$$

TABLE 3

CHILLER INVESTMENT AND NONFUEL PERIODIC MAINTENANCE COSTS (15)

Chiller Size	(\$) Investment Cost	(\$) Major Overhaul (9yr)	(\$) Minor Overhaul (3yr)
20 Ton	10,000	2,000	250
40 Ton	18,000	3,500	300
60 Ton	22,000	5,000	350
120 Ton	40,000	7,800	500

TABLE 4
STORAGE TANK INVESTMENT COSTS

Storage Tank Size (KBTU)	Storage Tank Size (US GALS)	Investment Costs (DOLLARS)
4000	40016	19600
6000	60024	29400
11000	110044	53140
17000	170068	83660

The cost time relationship for Buildings 20040 and 20050 are shown in Figures 9 and 10. On the cost-time lines, costs occurring during a given year are assumed to occur all at the end of a year. The economic evaluation is accomplished using TLCC by summing:

- (a) The present value of investment costs minus salvage value.
- (b) The present value of future nonfuel operations and maintenance costs.
- (c) The present value of replacement costs.
- (d) The present value of energy costs for each alternative design [19:83].

The TLCC of Buildings 20040 and 20050 was calculated as follows:

(a) Present value of investment is calculated by taking 90 percent of cost of the reciprocating chiller and storage tank minus salvage value of zero.

(b) Present value of future nonfuel operations and maintenance is calculated by multiplying major and minor maintenance costs by Single Present Worth formula for the corresponding years.

(c) Present Value of replacement value is equal to zero because equipment life and study life are equal.

(d) Present Value energy costs are calculated by multiplying total energy costs from Tables 5-10, by the Modified Uniform Present Worth Formula. The values for peak demand, billing demand and KWH consumption are taken from Time-of-Use Electrical Usage Reports in Appendices C and D.

Results of the analysis are summarized in Table 11 and show the base case option, no chilled-water storage, to be the most economical.

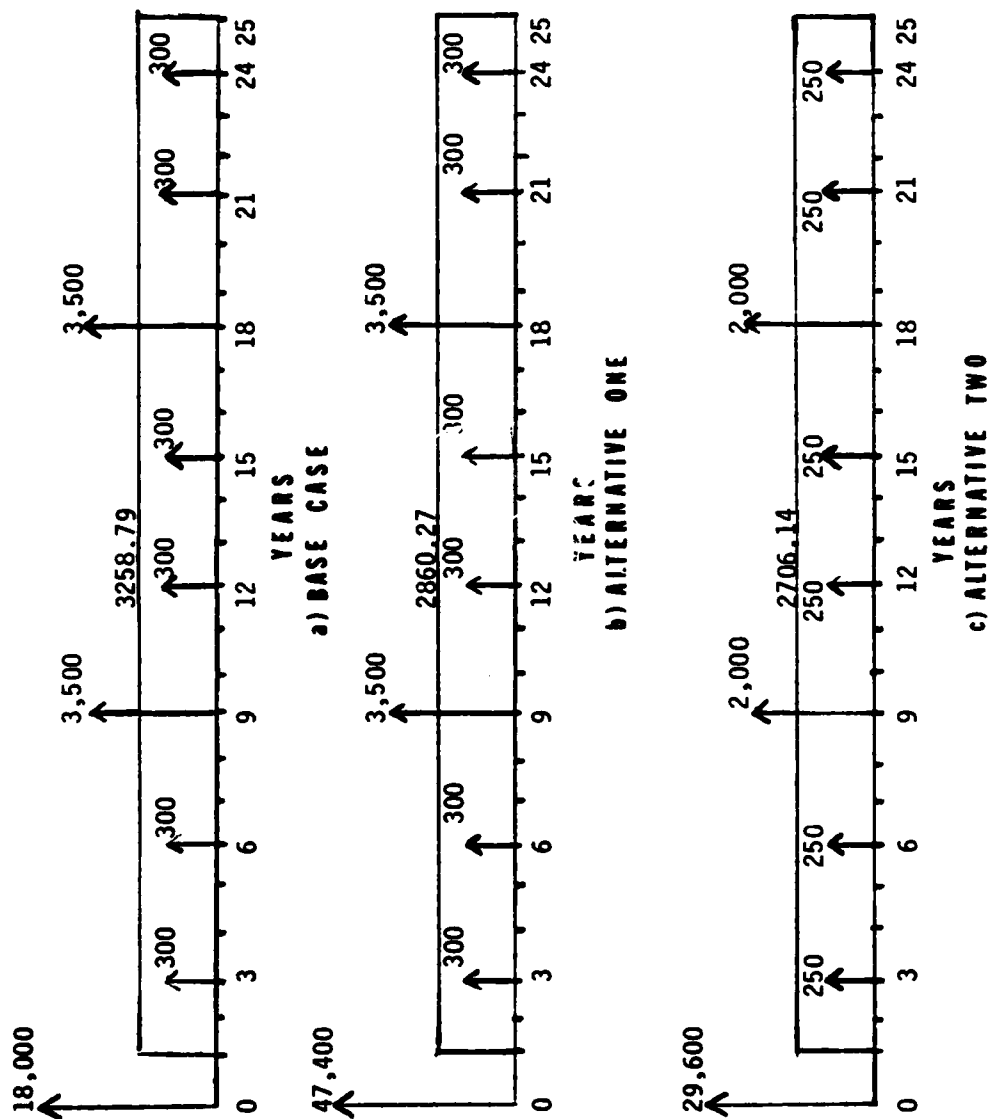


Fig. 9. Building 20040 Cost-Time Relationship (Dollars)

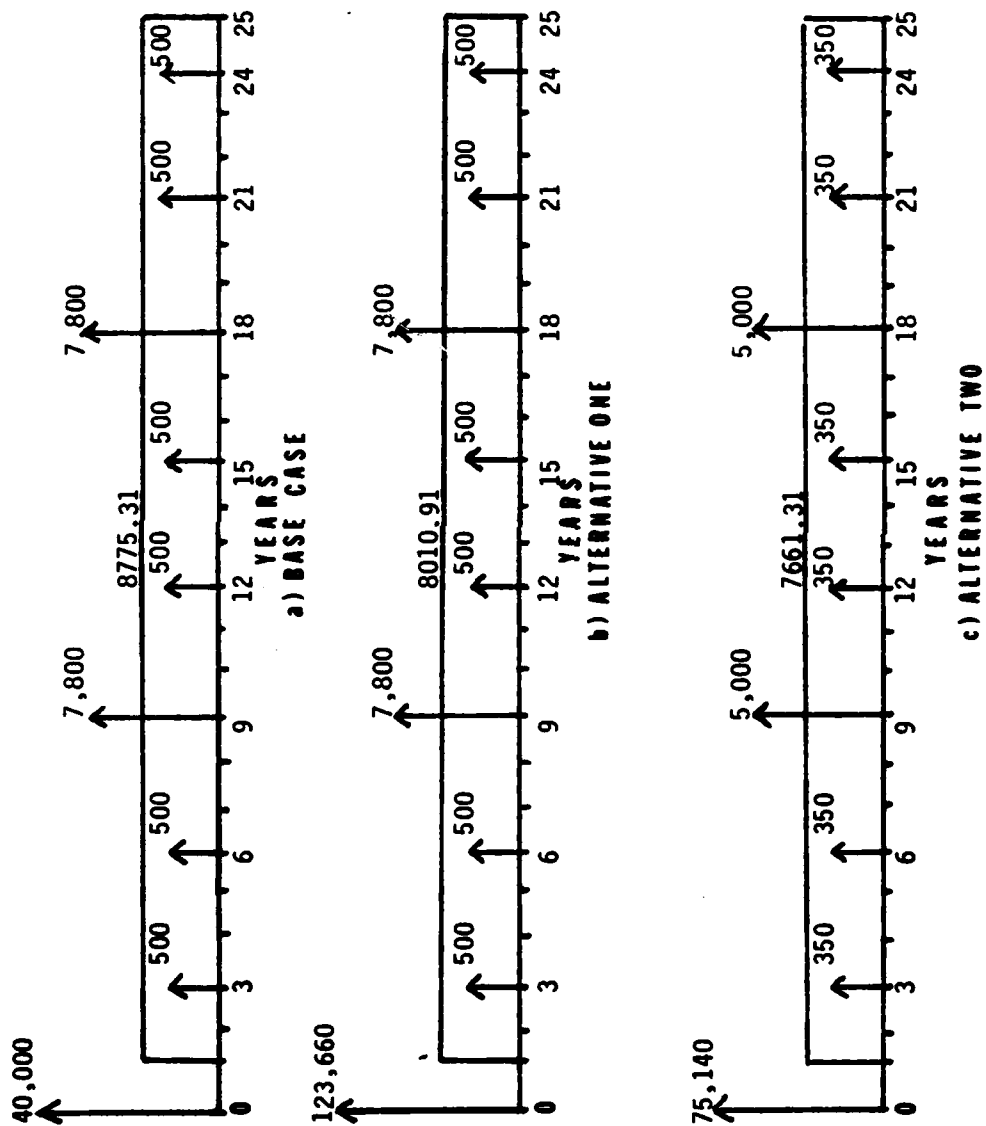


Fig. 10. Building 20050 Cost-Time Relationship (Dollars)

TABLE 5
BUILDING 20040 (BASE CASE) ENERGY COSTS (DOLLARS)

	JUN	JUL	AUG	SEP
Year Peak (kw)	114.30	114.30	114.30	114.30
Facility Charge	60.58	60.58	60.58	60.58
Monthly Billing Demand (kw)	111.54	114.30	113.76	99.55
Demand Charge	567.74	581.79	579.04	506.71
KWH (On-Peak/Off-Peak)	12672 13893	14411 15764	14149 15260	11974 13135
Energy Charge	158.4 27.79	180.14 31.53	176.86 30.52	149.68 26.27

1 Year Facility Charge	242.32
1 Year Demand Charge	2235.28
1 Year Energy Charge	781.19
Total Energy Costs	<u>3258.79</u>

TABLE 6

BUILDING 20040 (ALTERNATIVE 1) ENERGY COSTS (DOLLARS)

	JUN	JUL	AUG	SEP
Year Peak (kw)	104.57	104.57	104.57	104.57
Facility Charge	55.42	55.42	55.42	55.42
Monthly Billing Demand (kw)	100.98	104.57	104.38	85.51
Demand Charge	513.99	532.26	531.29	435.25
KWH (On-Peak/Off-Peak)	9747.5 14516	10576 16682	10526 16204	9643.9 12412
Energy Charge	121.84 29.03	132.20 33.36	131.58 32.41	120.55 24.82

1 Year Facility Charge	221.69
1 Year Demand Charge	2012.79
1 Year Energy Charge	625.79
Total Energy Costs	<u>2860.27</u>

TABLE 7

BUILDING 20040 (ALTERNATIVE 2) ENERGY COSTS (DOLLARS)

	JUN	JUL	AUG	SEP
Year Peak (kw)	89.536	89.536	89.536	89.536
Facility Charge	47.45	47.45	47.45	47.45
Monthly Billing Demand (kw)	89.227	89.536	87.915	88.206
Demand Charge	454.17	455.74	447.49	448.97
KWH (On-Peak/Off-Peak)	11885 12589	13210 13851	12811 13567	10685 11287
Energy Charge	148.56 25.18	165.13 27.70	160.14 27.13	133.56 22.57

5

1 Year Facility Charge	189.80
1 Year Demand Charge	1806.37
1 Year Energy Charge	709.97
Total Energy Costs	<u>2706.14</u>

TABLE 8

BUILDING 20050 (BASE CASE) ENERGY COSTS (DOLLARS)

	JUN	JUL	AUG	SEP
Year Peak (kw)	305.01	305.01	305.01	305.01
Facility Charge	161.66	161.66	161.66	161.66
Monthly Billing Demand (kw)	294.96	305.01	304.72	256.16
Demand Charge	1501.35	1552.50	1551.02	1303.85
KWH (On-Peak/Off-Peak)	35734 39682	40657 45211	39983 43805	34446 38629
Energy Charge	446.68 79.36	508.21 90.42	499.79 87.61	430.62 77.26

1 Year Facility Charge	646.64
1 Year Demand Charge	5908.72
1 Year Energy Charge	2219.95
Total Energy Costs	<u>8775.31</u>

TABLE 9

BUILDING 20050 (ALTERNATIVE 1) ENERGY COSTS (DOLLARS)

	JUN	JUL	AUG	SEP
Year Peak (kw)	289.02	289.02	289.02	289.02
Facility Charge	153.18	153.18	153.18	153.18
Monthly Billing Demand (kw)	289.02	288.07	286.75	243.74
Demand Charge	1471.11	1466.28	1459.56	1240.64
KWH (On-Peak/Off-Peak)	27290 41660	29418 47646	29304 46320	27275 36624
Energy Charge	341.13 83.32	367.73 95.29	366.30 92.64	340.94 73.25

1 Year Facility Charge	612.72
1 Year Demand Charge	5637.59
1 Year Energy Charge	1760.60
Total Energy Costs	<u>8010.91</u>

TABLE 10

BUILDING 20050 (ALTERNATIVE 2) ENERGY COSTS (DOLLARS)

	JUN	JUL	AUG	SEP
Year Peak (kw)	232.56	232.56	232.56	232.56
Facility Charge	123.26	123.26	123.26	123.26
Monthly Billing Demand (kw)	232.56	232.56	231.77	229.18
Demand Charge	1183.73	1183.73	1179.71	1166.52
KWH (On-Peak/Off-Peak)	33532 36196	37429 39103	36356 38435	30622 32834
Energy Charge	419.15 72.39	467.86 78.21	454.45 76.87	382.78 65.67

1 Year Facility Charge	930.24
1 Year Demand Charge	4713.69
1 Year Energy Charge	2017.38
Total Energy Costs	<u>7661.31</u>

TABLE 11

SUMMARY OF TLCC'S FOR BUILDING 20040 AND 20050 (DOLLARS)

	PV of INVESTMENT	PV of O&M	PV of ENERGY	TLCC
Building 20040				
Base	16,200	3,758	38,942	58,900
Alt 1	42,660	3,758	34,180	80,598
Alt 2	26,640	2,362	32,338	61,340
Building 20050				
Base	36,000	7,914	104,865	148,779
Alt 1	111,294	7,914	95,730	214,938
Alt 2	67,626	5,154	91,553	164,333

Adjusted Economic Analysis

The TLCC analysis presented so far deals with Buildings 20040 and 20050 as individual entities. That is, Building 20040 or 20050 is the only contributor to the electric utility bill. An adjusted economic analysis is now presented showing the effect of grouping buildings together for utility billing purposes.

Electric utility billing can be based on consumption from a number of buildings serviced by a single electric meter; such a case is common within the Department of Defense. In this case, the facility charges and demand charges are based on the peak demand through the electric meter, not for a particular building.

Adjustments to the TLCC analysis are made assuming Building 20040 or 20050 is grouped together with other buildings for electric billing based on the occurrence of peak loads. The adjusted analysis assumes another building serviced by the same electric meter as Building 20040 or 20050 has a peak electric demand during the on-peak period. The peak demand from the other building is an order of magnitude higher than that of Building 20040 or 20050. And, the on-peak demand from the other building occurs at the same time as the on-peak, peak demand for each option of Building 20040 and 20050.

The peak demand for the base case and alternative two for Buildings 20040 and 20050 occur during the on-peak period. Therefore, the peak demand will contribute directly to the facility charges and demand charges for the grouping of buildings.

The peak demand for alternative one, running the chiller at night only, occurs during the off-peak period. Therefore, the peak demand does not contribute to the facility charges and demand charges for the grouping of buildings. The contribution to the facility charges and demand charges are based on the peak demand during the on-peak period. The TLCC's for alternative one for buildings 20040 and 20050 are adjusted for the facility charges and demand charges based on the on-peak period peak demand. The adjusted energy costs are shown in Tables 12 and 13 and the adjusted TLCC's are shown in Table 14. The base case option, no chilled-water storage, remains the most economical; however, the economics of alternative one are improved.

Sensitivity Analysis

Finally, the sensitivity of the TLCC analysis to changes in storage tank construction costs should be examined. The storage tank investment costs used in the TLCC analysis are calculated using a cost of 49¢/gal. The investment cost of 49¢/gal in Table 1 is based on a 300,000 gallon concrete tank with a moving baffle anti-blending system. The investment costs includes costs of tank construction, anti-blending system, piping, and control and instrumentation.

The storage tank construction costs in Table 1 were 30¢/gal. As reported in answering Research Question One, concrete tanks can be constructed for as little as 20¢/gal, and gunite and styrofoam tanks for as little as 15¢/gal. The storage tank investment costs are recalculated at 39¢ and 34¢ per gallon (construction costs of 20¢ and 15¢ per gallon, respectively) and the TLCC's are adjusted for the recalculations. Results

of the sensitivity analysis are summarized in Table 15. Alternative two, the small chiller supplemented with stored chilled-water, has the minimum TLCC for building 20040 with storage tank investment costs of 39¢ and 34¢ per gallon. The base case remains the most economical for building 20050.

TABLE 12

BUILDING 20040 (ALTERNATIVE 1) ADJUSTED ENERGY COSTS (DOLLARS)

	JUN	JUL	AUG	SEP
Year Peak (kw)	63.11	63.11	63.11	63.11
Facility Charge	33.45	33.45	33.45	33.45
Monthly Billing Demand (kw)	63.11	63.11	63.11	63.11
Demand Charge	321.23	321.23	321.23	321.23

1 Year Facility Charge	133.80
1 Year Demand Charge	1284.92
1 Year Energy Charge	625.79
Total Adjusted Energy Charge	<u>2044.51</u>

TABLE 13
BUILDING 20050 (ALTERNATIVE 1) ADJUSTED ENERGY COSTS (DOLLARS)

	JUN	JUL	AUG	SEP
Year Peak (kw)	188.72	188.72	188.72	188.72
Facility Charge	100.02	100.02	100.02	100.02
Monthly Billing Demand (kw)	188.72	188.72	188.72	188.72
Demand Charge	960.58	960.58	960.58	960.58

1 Year Facility Charge	400.08
1 Year Demand Charge	3842.33
1 Year Energy Charge	1760.60
Total Adjusted Energy Charge	<u>6003.01</u>

TABLE 14

SUMMARY OF ADJUSTED TLCC'S FOR BUILDINGS 20040 AND 20050 (DOLLARS)

	PV of INVESTMENT	PV of O&M	PV of ENERGY	TLCC
Building 20040				
Base	16,200	3,758	38,942	58,900
Alt 1	42,660	3,758	24,432	70,850
Alt 2	26,640	2,362	32,338	61,340
Building 20050				
Base	36,000	7,914	104,865	148,779
Alt 1	111,294	7,914	71,736	190,944
Alt 2	67,626	5,154	91,553	164,333

TABLE 15

SUMMARY OF SENSITIVITY ANALYSIS ON TLCC'S (DOLLARS)

<u>STORAGE TANK INVESTMENT COST</u>			
	<u>49¢/US GAL</u>	<u>39¢/US GAL</u>	<u>34¢/US GAL</u>
<u>Building 20040</u>			
Base Case	0	0	0
Alt 1	29,400	23,400	20,400
Alt 2	19,600	15,600	13,600
Adjusted Alt 1	29,400	23,400	20,400
<u>Building 20050</u>			
Base Case	0	0	0
Alt 1	83,660	66,590	58,050
Alt 2	53,140	42,300	36,870
Adjusted Alt 1	83,660	66,590	58,050
<u>TLCC'S BASED ON STORAGE TANK I.C.</u>			
	<u>49¢/US GAL</u>	<u>39¢/US GAL</u>	<u>34¢/US GAL</u>
<u>Building 20040</u>			
Base Case	58,900	58,900	58,900
Alt 1	80,598	75,198	72,498
Alt 2	61,340	57,740	55,940
Adjusted Alt 1	70,850	65,450	62,750
<u>Building 20050</u>			
Base Case	148,779	148,779	148,779
Alt 1	214,938	199,575	191,889
Alt 2	164,333	154,577	149,690
Adjusted Alt 1	190,944	175,581	167,895

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Research Question One. The current methods for storing chilled-water were described in terms of construction materials and anti-blending systems. Storage tank construction materials were evaluated by comparing material costs. Materials available for use in constructing storage tanks included steel, concrete, gunite, and styrofoam. The steel tank costs are 50¢/gal as compared to 20¢/gal for concrete and 15¢/gal for gunite and styrofoam.

The effective operation of a chilled-water air conditioning system with storage requires a means of preventing blending of the chilled-water and warmer return water. Current anti-blending methods can be classified as fixed baffle, empty tank, or moving partition. The anti-blending systems were evaluated by comparing the effectiveness of the anti-blending system and costs. The fixed baffle method uses weirs (dams) to separate compartments in the tanks. The fixed baffle system does not physically separate the chilled and return water and is only partially effective in preventing blending. The empty tank method uses an empty compartment in the storage tank as a buffer between the chilled and return water. Maintaining the empty compartment buffer requires automation of the compartment

isolation and manifold valves. Prevention of blending relies on the effective operation of the automated control system. The moving partition method uses a floating membrane attached to the side of the storage tank to prevent blending. The membrane moves up and down automatically as the volume of chilled and return water changes and maintains a physical barrier between the chilled and return water.

Resolution of Research Question One. Currently, a gunite or styro-foam storage tank with a moving partition anti-blending system is the most desirable method for storing chilled-water. Gunite and styrofoam have the least expensive construction costs. The moving partition maintains a physical barrier between the chilled and return water without depending on an automated control system and has the least cost per gallon.

Research Question Two. The economics of producing chilled-water during off-peak periods with a time-of-use utility rate schedule were investigated using minimum total life-cycle cost (TLCC) as a criteria. The procedures used in the TLCC analysis were established by DOE. The analysis included computer simulation of two different sized buildings at Wright-Patterson AFB to gather electrical consumption data. The building simulations included three options: (1) a base case with no chilled-water storage; (2) alternative one, producing all chilled-water during off-peak periods; and (3) alternative two, supplementing a smaller chiller with chilled-water produced at night. The buildings simulated were 20040 and 20050.

The TLCC included investment costs, maintenance costs, and energy costs derived from the electrical consumption data. At first, the buildings were analyzed as individual entities, treating the buildings as the only determinants of the electric utility bill. Then, the buildings were treated as one of a group of buildings and the TLCC's were adjusted for savings on electrical demand charges. Finally, a sensitivity analysis was performed to investigate the influence of using different storage tank materials with differing investment costs.

The base case, no chilled-water storage, has the minimum TLCC for both buildings when the buildings are treated as individual entities with concrete storage tanks. Investment costs of both of these concrete tanks was set at 49¢/gal. Alternatives one and two have smaller energy costs than those of the base case, but these savings are insufficient to amortize the added investment costs of the storage tanks. The TLCC's of alternative two came closer to those of the base case. The installation of a smaller chiller reduced chiller investment costs, storage tank investment costs, and peak electrical demand charges for the buildings compared to alternative one.

The base case also has the minimum TLCC when buildings 20040 and 20050 were treated as one of a group of buildings and concrete storage tank investment costs were 49¢/gal. The electrical peak demand charges are reduced for alternative one, operating the chiller only at night, because the peak electrical demand of the chiller is exceeded by the larger daytime peak demand of the other buildings. However, operating the smaller chiller with supplemental chilled water is still more economical than operating a considerably larger chiller only at night.

A sensitivity analysis was performed for the range of storage tank construction costs found in current literature. The original TLCC's were recalculated to reflect use of concrete storage tanks with investment costs of 39¢/gal and gunite or styrofoam tanks with investment costs of 34¢/gal. With storage tank construction costs of 39¢ and 34¢ per gal, alternative two for building 20040, the smaller building, was the most economical, while the base case for building 20050 remained the most economical.

Resolutions of Research Question Two. The economics of chilled-water storage for air conditioning applications with time-of-use electrical rates based on a TLCC analysis is sensitive to storage tank investment costs and size of the air conditioning load. Alternative two for building 20040 has the minimum TLCC when storage tank investment costs are reduced to 39¢/gal. The economics of alternative two for building 20050 will become the most economical if storage tank investment costs are reduced slightly below 34¢/gal. The decision whether or not to install chilled-water storage will, therefore, greatly depend on the ability to minimize initial investment costs.

Recommendations for Further Research

Based on the minimal information available on chilled-water storage and the results of the economic analysis performed in this thesis, several recommendations are made for further research.

Buildings with chilled-water storage applications found in the literature were all under construction or due to be completed in the 1980-1981 time frame, the time period of this research. These projects can be

used as sources of information on investment, operation and maintenance costs of the storage systems in future research.

The economic analysis considered only the utility rate schedule for Dayton Power and Light. Information on the structure of other utility rate schedules in effect in other areas of the country could be obtained and applied to the electrical consumption data from this simulation.

Finally, additional simulations need to be performed to verify the electrical consumption data provided by the BLAST algorithm used in this research.

APPENDICES

APPENDIX A
BLAST INPUT LISTING FOR
BUILDING 20040

```

00010 *****
00020 **BUILDING LEAD-IN**
00030 *****
00040 ** BUILDING NUMBER = 20040
00050 ** ENGINEER = MCMULLEN,PAPAPROTOP
00060 ** AUTOVON PHONE NUMBER = 787-4107
00070 ** TOTAL REAL PROPERTY AREA OF BUILDING = 21543
00080 ** PROJECT AREA = 21543
00090 ** MULTI-PURPOSE BUILDING (B)
00100 ** FUEL TYPE = COAL
00110 ** CATCODE = 550145
00120 ** CAT DESCRIPTION = DISP OCC HEALTH
00130 ** BASE CASE = EXISTING BUILDING
00140 ** ALT 1 = COLD STORAGE CHILLER 12 HOUR OPERATION
00150 ** ALT 2 = COLD STORAGE CHILLER 24 HOUR OPERATION
00160 ** FY 84 BETS PROGRAM
00170 ** BASE = WRIGHT PATERSON

```

00180 ** LOCATION = DAYTON, OHIO
 00190 ** MAJOR COMMAND = AFLC
 00200 ** MAJCOM REVIEWER = _____
 00210 **
 00220 **
 00230 *****
 00240 *****
 00250 BEGIN INPUT ;
 00260 RUN CONTROL: NEW ZONES, NEW AIR SYSTEMS, CENTRAL PLANT,
 00270 REPORTS (WALLS, COIL LOADS, SYSTEM, ECIP) ;
 00280 DEFINE LOCATION ;
 00290 WRIGHT-PATTERSON = (LAT = 39.49, LONG = 84.03, TZ = 5) ;
 00300 END LOCATION ;
 00310 DEFINE DESIGN DAYS ;
 00320 WRIGHT-PATTERSON WINTER = (HIGH = 25, LOW = 3, WB = 22,
 00330 DATE = 21 JAN, PRES = 391, WS = 1320, DIR = 225,
 00340 CLEARNESS = .95, WEEKDAY),

00350 WRIGHT-PATTERSON SPRING = (HIGH = 50, LOW = 32, WB = 45,
 00360 DATE = 21 MAR, PRES = 391, WS = 1320, DIR = 225,
 00370 CLEARNESS = .95, WEEKDAY).
 00380 WRIGHT-PATTERSON SUMMER = (HIGH = 89, LOW = 67, WB = 74,
 00390 DATE = 18 AUG, PRES = 391, WS = 660, DIR = 225,
 00400 CLEARNESS = .95, WEEKDAY).
 00410 WRIGHT-PATTERSON FALL = (HIGH = 84, LOW = 59, WB = 69,
 00420 DATE = 21 SEP, PRES = 392, WS = 840, DIR = 225,
 00430 CLEARNESS = .95, WEEKDAY).
 00440 END DESIGN DAYS :
 00450 *****
 00460 ** TO RUN A FULL YEAR SIMULATION, REMOVE THE "***" FROM IN FRONT OF **
 00470 ** WEATHER TAPE AND PUT THEM IN FRONT OF DESIGN DAYS. **
 00480 *****
 00490 *****
 00500 TEMPORARY WALLS :
 00510 MYWALL) = (A) - 1 IN STUCCO

00520	C7 - 8 IN LW CONCRETE BLOCK	.
00530	B1 - AIRSPACE RESISTANCE	.
00540	C2 - 4 IN LW CONCRETE BLOCK	.
00550	E1 - 3/4 IN PLASTER OR GYP BOARD) ;
00560	END WALLS :	
00570	*****	
00580	TEMPORARY WALLS :	.
00590	MYWALL2 = (C11 - 12 IN HW CONCRETE	.
00600	E1 - 3/4 IN PLASTER OR GYP BOARD) ;
00610	END WALLS :	
00620	*****	
00630	TEMPORARY ROOFS :	
00640	MYROOF1 = (ROOFING - ASPHALT ROLL	.
00650	C11 - 12 IN HW CONCRETE	.
00660	A3 - STEEL SIDING	.
00670	E4 - CEILING AIRSPACE	.
00680	E5 - ACOUSTIC TILE) ;

00690	END ROOFS :		
00700		*****	
00710	TEMPORARY ROOFS :		
00720	MYCEILI = (FINISH FLOORING - CARPET FIBROUS PAD)		,
00730		C11 - 12 IN HW CONCRETE) :
00740	END ROOFS :		
00750		*****	
00760	TEMPORARY FLOORS :		
00770	MYFLOOR1 = (E5 - ACOUSTIC TILF		,
00780		E4 - CEILING AIRSPACE	,
00790		C11 - 12 IN HW CONCRETE	,
00800		FINISH FLOORING - CARPET FIBROUS PAD) :
00810	END FLOORS :		
00820		*****	
00830	TEMPORARY FLOORS :		
00840	MYFLOOR2 = (DIRT 12 IN		,
00850		C10 - 8 IN HW CONCRETE	,

```

00860          FINISH FLOORING - CARPET FIBROUS PAD      ) :
00870      END FLOORS      :
00880      PROJECT = "ENERGY ANALYSIS OF BUILDING 20040      " :
00890      LOCATION = WRIGHT-PATTERSON :
00900          ** DESIGN DAYS = WRIGHT-PATTERSON WINTER, WRIGHT-PATTERSON SUMMER :
00910      WEATHER TAPE FROM 01 JAN 68 THRU 30 DEC 68 :
00920      GROUND TEMPERATURES = (42,42,46,46,46,63,63,63,59,59,42) :
00930      *****
00940      **BUILDING DESCRIPTION**
00950      *****
00960      BEGIN BUILDING DESCRIPTION:
00970      BUILDING = "20040 MEDICAL DISPEN":
00980      DIMENSIONS: N=0,F=90,W=270,S=180:
00990      NORTH AXIS = 0:
01000      *****
01010      ZONE 1 " CENTRAL BUILDING UNIT      " :
01020      **

```

01030	ROOFS:		
01040	STARTING AT (0	.0	.500) FACING (S)
01050	MYROOF1	(190	BY 40)
01060		**	
01070	EXTERIOR WALLS:		
01080	FACING (S) MYWALL1	(40	BY 8) WITH
01090	WINDOWS OF TYPE SINGLE PANE WITH DRAPES		
01100		(18	BY 4.7) AT (0,0),
01110	FACING (E) MYWALL1	(110	BY 8) WITH
01120	WINDOWS OF TYPE SINGLE PANE WITH DRAPES		
01130		(44	BY 4.7) AT (0,0) WITH
01140	DOORS OF TYPE GLASS DOOR		
01150		(6	BY 7) AT (0,0),
01160	FACING (N) MYWALL1	(40	BY 8) WITH
01170	WINDOWS OF TYPE SINGLE PANE WITH DRAPES		
01180		(18	BY 4.7) AT (0,0),
01190	FACING (W) MYWALL1	(190	BY 8) WITH

01200	WINDOWS	OF TYPE SINGLE PANE WITH DRAPES	
01210		(84 BY 4.7) AT (0,0) WITH	
01220	DOORS	OF TYPE GLASS DOWN	
01230		(12 BY 7) AT (0,0) :	
01240		**	
01250	PARTITIONS :		
01260	FACING (N) PARTITION	23 (80 BY 8) :	
01270		**	
01280	FLOORS :		
01290	FACING (E) MYFLOOR	1 (190 BY 40) :	
01300		**	
01310	CONTROLS =	NIGHT AND WEEKEND SETBACK WITH DUAL THROTTLING RANGES .	
01320		462 HEATING, 246 COOLING :	
01330	PEOPLE =	15, OFFICE OCCUPANCY :	
01340	LIGHTS =	78, OFFICE LIGHTING :	
01350	ELECTRIC EQUIPMENT =	15, OFFICE OCCUPANCY :	
01360	INFILTRATION =	1265, OFFICE LIGHTING :	

01370 END:

01380 *****

01390 ZONE 2 " RIGHT BUILDING UNIT "

01400 **

01410 ROOFS:

01420 STARTING AT (0 ,0 ,500) FACING (S)

01430 MYR(X)FI (40 BY 76):

01440 **

01450 EXTERIOR WALLS:

01460 FACING (S) MYWALLI (76 BY 8) WITH

01470 WINDOWS OF TYPE SINGLE PANE WITH DRAPES

01480 (38 BY 4.7) AT (0,0),

01490 FACING (E) MYWALLI (40 BY 8) WITH

01500 WINDOWS OF TYPE SINGLE PANE WITH DRAPES

01510 (16 BY 4.7) AT (0,0),

01520 FACING (N) MYWALLI (76 BY 8) WITH

01530 WINDOWS OF TYPE SINGLE PANE WITH DRAPES

01540 (38 BY 4.7) AT (0,0) WITH
 01550 DOORS OF TYPE SOLID WOOD DOOR
 01560 (2.7 BY 7) AT (0,0) ;
 01570 **
 01580 PARTITIONS ;
 01590 FACING (N) PARTITION23 (40 BY 8) ;
 01600 **
 01610 SLAB ON GRADE FLOOR ;
 01620 FACING (E) MYFLOOR2 (40 BY 76) ;
 01630 **
 01640 CONTROLS = NIGHT AND WEEKEND SFTBACK WITH DUAL THROTTLING RANGES .
 01650 184 HEATING, 98COOLING ;
 01660 PEOPLE = 15, OFFICE OCCUPANCY ;
 01670 LIGHTS = 40, OFFICE LIGHTING ;
 01680 FLECTRIC EQUIPMENT = 6, OFFICE OCCUPANCY ;
 01690 INFILTRATION = 506, OFFICE LIGHTING ;
 01700 END ;

01710 *****

01720 ZONE 3 " LEFT BUILDING UNIT "

01730 **

01740 ROOFS:

01750 STARTING AT (0 0 0 500) FACING (S)

01760 MYROOF (40 BY 76)

01770 **

01780 EXTERIOR WALLS:

01790 FACING (S) MYWALL (76 BY 8) WITH

01800 WINDOWS OF TYPE SINGLE PANE WITH DRAPES

01810 (38 BY 4.7) AT (0,0),

01820 FACING (E) MYWALL (40 BY 8),

01830 FACING (N) MYWALL (76 BY 8) WITH

01840 WINDOWS OF TYPE SINGLE PANE WITH DRAPES

01850 (34 BY 4.7) AT (0,0) WITH

01860 DOORS OF TYPE SOLID WOOD DOOR

01870 (2.7 BY 7) AT (0,0)

02050	CEILINGS:			
02060	FACING (S) MYCELI	(93	BY 38.6) :	
02070		**		
02080	EXTERIOR WALLS:			
02090	FACING (N) MYWALL1	(40	BY 5) ,	
02100	FACING (W) MYWALL1	(93	BY 5.6) WITH	
02110	WINDOWS OF TYPE SINGLE PANE WITH DRAPES			
02120		(22	BY 2.75) AT (0.0) :	
02130		**		
02140	PARTITIONS:			
02150	FACING (N) PARTITION23	(38.6	BY 9.75) :	
02160		**		
02170	BASEMENT WALLS:			
02180	FACING (N) MYWALL2	(133	BY 4.15) ,	
02190	FACING (N) MYWALL2	(93	BY 9.75) :	
02200		**		
02210	SLAB ON GRADE FLOOR:			

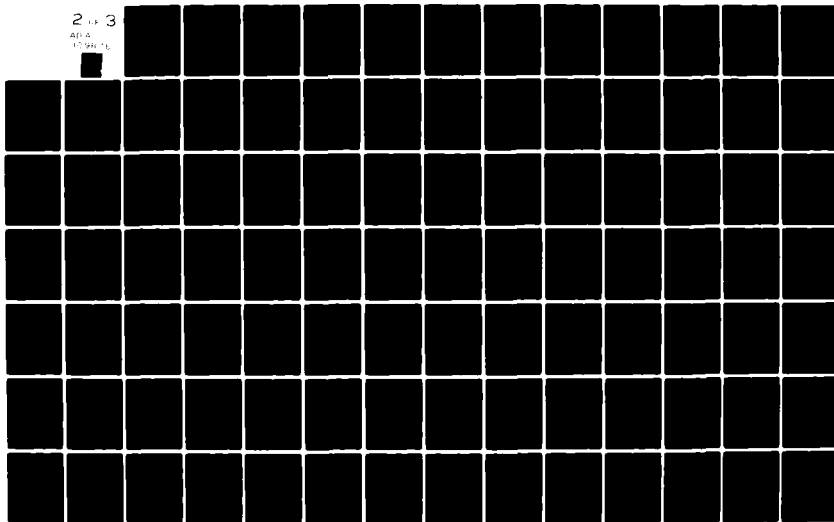
02220 FACING (E) MYFL00R2 (93 BY 40) :
 02230 **
 02240 CONTROLS = NIGHT AND WEEKEND SETBACK WITH DUAL THROTTLING RANGES :
 02250 100 HEATING, 51COOLING:
 02260 PFOPLE = 5, OFFICE OCCUPANCY :
 02270 LIGHTS = 13, OFFICE LIGHTING :
 02280 INFILTRATION = 250, OFFICE LIGHTING :
 02290 END:
 02300 *****
 02310 ZONE 5 " SOUTH BASEMENT " :
 02320 **
 02330 CEILINGS:
 02340 FACING (S) MYCEIL1 (96 BY 39.6) :
 02350 **
 02360 EXTERIOR WALLS:
 02370 FACING (W) MYWALL1 (96 BY 5.6) WITH
 02380 WINDOWS OF TYPE SINGLE PANE WITH DRAPES

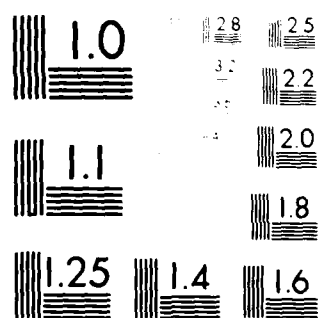
02390	(17.4 BY 2.75) AT (0,0),
02400	FACING (S) MYWALL1 (40 BY 9.75) WITH
02410	WINDOWS OF TYPE SINGLE PANE WITH DRAPES
02420	(5.5 BY 2.75) AT (0,0) WITH
02430	DOORS OF TYPE GLASS DOOR
02440	(6 BY 7) AT (0,0) :
02450	**
02460	PARTITIONS :
02470	FACING (N) PARTITION23 (38.6 BY 9.75) :
02480	**
02490	BASEMENT WALLS :
02500	FACING (N) MYWALL2 (96 BY 9.75) :
02510	FACING (N) MYWALL2 (96 BY 4.15) :
02520	**
02530	SLAB ON GRADE FLOOR :
02540	FACING (E) MYFLOOR2 (96 BY 40) :
02550	**

AD-A109 876 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL--ETC F/G 13/1
AN ECONOMIC ANALYSIS OF AIR-CONDITIONING SYSTEMS WITH OFF-PEAK --ETC(U)
SEP 81 B J MCMULLEN, N D PAPAPROKOPIOU
UNCLASSIFIED AFIT-LSSR-66-81 NL

2 of 3

AD-A
109876





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

02560 CONTROLS = NIGHT AND WEEKEND SETBACK WITH DUAL THROTTLING RANGES .

02570 100 HEATING, 52COOLING:

02580 PEOPLE = 5, OFFICE OCCUPANCY ;

02590 LIGHTS = 10, OFFICE LIGHTING ;

02600 INFILTRATION = 250, OFFICE LIGHTING ;

02610 END;

02620 *****

02630 END BUILDING DESCRIPTION;

02640 *****

02650 **

02660 *****

02670 *****

02680 *****

02690 *****

02700 BEGIN FAN SYSTEM DESCRIPTION;

02710 ** SYSTEM 1

02720 MULTIZONE SYSTEM 1" MULTIZONE FAN SYSTEM 1 "

02730 SERVING ZONES 1, 2, 3

02740

02750 FOR ZONE 1:

02760 SUPPLY AIR VOLUME = 8990.1

02770 EXHAUST AIR VOLUME = 0

02780 END:

02790

02800 FOR ZONE 2:

02810 SUPPLY AIR VOLUME = 2975.1

02820 EXHAUST AIR VOLUME = 0

02830 END:

02840

02850 FOR ZONE 3:

02860 SUPPLY AIR VOLUME = 2575.1

02870 EXHAUST AIR VOLUME = 0

02880 END:

02890

02900 OTHER SYSTEM PARAMETERS :		
02910 HEATING COIL CAPACITY =	3412000	:
02920 HEATING COIL ENERGY SUPPLY =	STFAM	:
02930 SUPPLY FAN PRESSURE =	2.0	:
02940 EXHAUST FAN PRESSURE =	1	:
02950 RETURN FAN PRESSURE =	0.0	:
02960 SUPPLY FAN EFFICIENCY =	.7	:
02970 EXHAUST FAN EFFICIENCY =	.7	:
02980 RETURN FAN EFFICIENCY =	.7	:
02990 COLD DECK CONTROL =	FIXED SET POINT	:
03000 COLD DECK TEMPERATURE =	55	:
03010 COLD DECK THROTTLING RANGE =	10	:
03020 HOT DECK CONTROL =	OUTSIDE AIR CONTROLLED	:
03030 HOT DECK THROTTLING RANGE =	10	:
03040 HOT DECK CONTROL SCHEDULE =	(140 AT 0, 70 AT 70)	:
03050 WEEKDAY MINIMUM OUTSIDE AIR SCHEDULE =	(00 TO 24-.1)	:
03060 WEEKDAY MAXIMUM OUTSIDE AIR SCHEDULE =	(00 TO 24-.1)	:

03070	WEEKEND MINIMUM OUTSIDE AIR SCHEDULE =	(00 TO 24-.1)	:
03080	WEEKEND MAXIMUM OUTSIDE AIR SCHEDULE =	(00 TO 24-.1)	:
03090	MIXED AIR CONTROL =	FIXED PERCENT	:
03100	**PREHEAT COIL LOCATION =	NONE	:
03110	**PREHEAT TEMPERATURE =	46.4	:
03120	GAS BURNER EFFICIENCY =	.7	:
03130	**PREHEAT ENERGY SUPPLY =	HOT WATER	:
03140	**PREHEAT COIL CAPACITY =	0.0	:
03150	**HUMIDIFIER TYPE =	NONE	:
03160	END OTHER SYSTEM PARAMETERS:		
03170		*****	
03180	COOLING COIL DESIGN PARAMETERS:		
03190	COIL TYPE =	CHILLED WATER	:
03200	AIR VOLUME FLOW RATE =	14540.	:
03210	BAROMETRIC PRESSURE =	397	:
03220	AIR FACE VELOCITY =	490	:
03230	ENTERING AIR DRY BULB TEMPERATURE =	85	:

03240 ENTERING AIR WET BULB TEMPERATURE =	64	:
03250 LEAVING AIR DRY BULB TEMPERATURE =	55	:
03260 LEAVING AIR WET BULB TEMPERATURE =	52.7	:
03270 ENTERING WATER TEMPERATURE =	45	:
03280 LEAVING WATER TEMPERATURE =	55	:
03290 WATER VELOCITY =	275	:
03300 WATER VOLUME FLOW RATE =	12.	:

03310 END COOLING COIL DESIGN PARAMETERS:

03320		
03330 EQUIPMENT SCHEDULES:		
03340 SYSTEM OPERATION =	INTERMITTENT	:
03350 WEEKDAY SYSTEM SCHEDULE =	(00 TO 24 - ON) :
03360 WEEKEND SYSTEM SCHEDULE =	(00 TO 24 - OFF) :
03370 WEEKDAY HEATING SCHEDULE =	(00 TO 24-ON)	:
03380 WEEKEND HEATING SCHEDULE =	(00 TO 24-ON)	:
03390 WEEKDAY COOLING SCHEDULE =	(00 TO 24-ON)	:
03400 WEEKEND COOLING SCHEDULE =	(00 TO 24-ON)	:

03410	HEATING CAPACITY ON FROM 01 OCT	THRU 31 MAY	:
03420	COOLING CAPACITY ON FROM 01 JUN	THRU 30 SEP	:
03430	END EQUIPMENT SCHEDULES:		
03440	END SYSTEM:		
03450			*****
03460			*****
03470	** SYSTEM 2		
03480	MULTIZONE SYSTEM		2 ND MULTIZONE FAN SYSTEM
03490	SERVING ZONES 4, 5		:
03500			*****
03510	FOR ZONE 4:		
03520	SUPPLY AIR VOLUME =	1600.:	
03530	EXHAUST AIR VOLUME = 0		:
03540	END:		
03550			*****
03560	FOR ZONE 5:		
03570	SUPPLY AIR VOLUME =	1730.:	

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03580 EXHAUST AIR VOLUME = 0      ;
03590 END ;
03600
          *****
03610 OTHER SYSTEM PARAMETERS ;
03620 HEATING COIL CAPACITY =      3412000      ;
03630 HEATING COIL ENERGY SUPPLY = STEAM      ;
03640 SUPPLY FAN PRESSURE =      2.0      ;
03650 EXHAUST FAN PRESSURE =      1      ;
03660 RETURN FAN PRESSURE =      0.0      ;
03670 SUPPLY FAN EFFICIENCY =      .7      ;
03680 EXHAUST FAN EFFICIENCY =      .7      ;
03690 RETURN FAN EFFICIENCY =      .7      ;
03700 COLD DECK CONTROL =      FIXED SET POINT      ;
03710 COLD DECK TEMPERATURE =      55      ;
03720 COLD DECK THROTTLING RANGE =      10      ;
03730 HOT DECK CONTROL =      OUTSIDE AIR CONTROLLED      ;
03740 HOT DECK THROTTLING RANGE =      10      ;

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03750 HOT DECK CONTROL SCHEDULE = (140 AT 0, 70 AT 70) ;
03760 WEEKDAY MINIMUM OUTSIDE AIR SCHEDULE = (00 TO 24-.1) ;
03770 WEEKDAY MAXIMUM OUTSIDE AIR SCHEDULE = (00 TO 24-.1) ;
03780 WEEKEND MINIMUM OUTSIDE AIR SCHEDULE = (00 TO 24-.1) ;
03790 WEEKEND MAXIMUM OUTSIDE AIR SCHEDULE = (00 TO 24-.1) ;
03800 MIXED AIR CONTROL = FIXED PERCENT ;
03810 **PREHEAT COIL LOCATION = NONE ;
03820 **PREHEAT TEMPERATURE = 46.4 ;
03830 GAS BURNER EFFICIENCY = .7 ;
03840 **PREHEAT ENERGY SUPPLY = HOT WATER ;
03850 **PREHEAT COIL CAPACITY = 0.0 ;
03860 **HUMIDIFIER TYPE = NONE ;
03870 END OTHER SYSTEM PARAMETERS ;
03880 *****
03890 COOLING COIL DESIGN PARAMETERS ;
03900 COIL TYPE = CHILLED WATER ;
03910 AIR VOLUME FLOW RATE = 3330. ;

03920 BAROMETRIC PRESSURE = 397 ;
 03930 AIR FACE VELOCITY = 490 ;
 03940 ENTERING AIR DRY BULB TEMPERATURE = 85 ;
 03950 ENTERING AIR WET BULB TEMPERATURE = 64 ;
 03960 LEAVING AIR DRY BULB TEMPERATURE = 55 ;
 03970 LEAVING AIR WET BULB TEMPERATURE = 52.7 ;
 03980 ENTERING WATER TEMPERATURE = 45 ;
 03990 LEAVING WATER TEMPERATURE = 55 ;
 04000 WATER VELOCITY = 275 ;
 04010 WATER VOLUME FLOW RATE = 3. ;
 04020 END COOLING COIL DESIGN PARAMETERS ;

04030
 04040 EQUIPMENT SCHEDULES ;
 04050 SYSTEM OPERATION = INTERMITTENT ;
 04060 WEEKDAY SYSTEM SCHEDULE = (00 TO 24 - ON) ;
 04070 WEEKEND SYSTEM SCHEDULE = (00 TO 24 - OFF) ;
 04080 WEEKDAY HEATING SCHEDULE = (00 TO 24-ON) ;

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04090 WEEKEND HEATING SCHEDULE = (00 TO 24-0N) ;
04100 WEEKDAY COOLING SCHEDULE = (00 TO 24-0N) ;
04110 WEEKEND COOLING SCHEDULE = (00 TO 24-0N) ;
04120 HEATING CAPACITY ON FROM 01 OCT THRU 31 MAY ;
04130 COOLING CAPACITY ON FROM 01 JUN THRU 30 SEP ;
04140 END EQUIPMENT SCHEDULES;
04150 END SYSTEM;
04160 *****
04170 *****
04180 END FAN SYSTEM DESCRIPTION;
04190 BEGIN CENTRAL PLANT DESCRIPTION;
04200 *****
04210 *****
04220 ECIP PARAMETERS;
04230 BUILDING AREA = 21543;
04240 MAJCOM = "AFLC";
04250 BUILDING NUMBER = "20040";

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04260 AIR FORCE BASE = "WRIGHT-PATTERSON"
04270 USE = "DISP OCC HEALTH"
04280 FUEL TYPE = "COAL"
04290 END ECIP
04300 PLANT 1 "CENTRAL PLANT SYSTEM 1"
04310 SERVING SYSTEM 1,2
04320 EQUIPMENT SELECTION
04330 1 BOILER OF SIZE 1033.
04340 1 RECIPROCATING CHILLER OF SIZE 480.
04350 END EQUIPMENT SELECTION
04360 *****
04370 SPECIAL PARAMETERS
04380 HFUELB = 12250.
04390 TOTUEF = .294
04400 SHATB = 10.3
04410 RFLASH = .1
04420 END SPECIAL PARAMETERS

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04430 *****
04440 PART LOADS RATIO:
04450 RECIPROCATING CHILLER (MIN=.02,MAX=1.2,BEST=.65,ELECTRICAL=.3129)
04460 END PART LOAD RATIOS:
04470 *****
04480 SCHEDULE:
04481 WEEKDAY RATE SCHEDULE2 =
04482 (2,2,2,2,2,2,2,2,2,2,1,1,1,1,1,1,1,1,1,2,2,2,2):
04483 WFEKEND RATE SCHEDULE2 =
04484 (2,2,2,2,2,2,2,2,2,2,1,1,1,1,1,1,1,1,1,2,2,2,2):
04485 WFEKDAY RATE SCHEDULE1 =
04486 (4,4,4,4,4,4,4,4,3,3,3,3,3,3,3,3,3,3,3,4,4,4,4):
04487 WFEKEND RATE SCHEDULE1 =
04488 (4,4,4,4,4,4,4,4,3,3,3,3,3,3,3,3,3,3,3,4,4,4,4):
04489 RATE SCHEDULE2 ON FROM 01 JUN THRU 30 SEP:
04490 WEEKDAY HOT WATER=(07 TO 17 - 40,17 TO 24 - 7,
04500 24 TO 07 - 0 )

```

04510 WEEKEND HOT WATER=00 TO 24 - 0) ;

04520 END SCHEDULE ;

04530 *****

04540 LIFE CYCLE COST PARAMETERS:

04550 PROJECT LIFE = 25 ;

04560 UNIT LABOR COST = 19 ;

04570 END LIFE CYCLE COST PARAMETERS ;

04580 *****

04590 ENERGY COST ;

04600 ELECTRICITY ;

04610 ENERGY UNIT = 3.412, UNIT COST = .058 ,

04620 COST ESCALATION FACTOR = 0,

04630 MINIMUM MONTHLY CHARGE = 0,

04640 MINIMUM PEAK LOAD = 0,

04650 DEMAND CHARGE = 0 ,

04660 INFLATION = 7.5 ;

04670 *****

04680 BOILER FUEL \$

04690 ENERGY UNIT = 1000 , UNIT COST = 7.53 ,

04700 COST ESCALATION FACTOR = 0,

04710 MINIMUM MONTHLY CHARGE = 0,

04720 MINIMUM PEAK LOAD = 0,

04730 DEMAND CHARGE = 0,

04740 INFLATION = 7.53

04750 END ENERGY COST:

04760

04770 ACTUAL EQUIPMENT COST:

04780 BOILER \$

04790 SIZE = 1033.,

04800 COST = .01,

04810 HOURS TO MAJOR OVERHAUL = 50000.,

04820 MAJOR OVERHAUL COST = 0.,

04830 HOURS TO MINOR OVERHAUL = 15000.,

04840 MINOR OVERHAUL COST = 0.,

04450 CONSUMABLES =	0..
04860 MAINTENANCE =	0..
04870 LIFE =	1 00000.:
04880 RECIPROCATING CHILLER :	
04890 SIZE =	480..
04900 COST =	18000..
04910 HOURS TO MAJOR OVERHAUL =	50000..
04920 MAJOR OVERHAUL COST =	3500..
04930 HOURS TO MINOR OVERHAUL =	15000..
04940 MINOR OVERHAUL COST =	300..
04950 CONSUMABLES =	0..
04960 MAINTENANCE =	0..
04970 LIFE =	1 00000.:
04980 END ACTUAL EQUIPMENT COST:	
04990	
05000 OTHER COST PARAMETERS:	
05010 BUILDING CAPITAL COST =	0.:

05020	ANNUAL BUILDING MAINTENANCE =	0.3
05030	PERIODIC BUILDING COSTS =	0.0
05040	PERIOD =	0.3
05050	FAN SYSTEM CAPITAL COST =	0.3
05060	ANNUAL FAN SYSTEM MAINTENANCE =	0.3
05070	PERIODIC FAN SYSTEM COST =	0.0
05080	PERIOD =	0.3
05090	END OTHER COST PARAMETERS:	
05100	END PLANT:	
05110		*****
05120		*****
05130	PLANT 2 "COLD STORAGE CHILLER 12 HOUR OPERATION	"
05140	SERVING SYSTEM 1,2	:
05150	EQUIPMENT SELECTION:	
05160	1 COLD STORAGE TANK OF SIZE 6000.3	
05170	1 BOILER	OF SIZE 1033.3
05180	1 RECIPROCATING CHILLER	OF SIZE 480.3

05190 END EQUIPMENT SELECTION:

05200

05210 SPECIAL PARAMETERS:

05220 RUNTMCH = 12:

05230 RUNTMB = 1:

05240 MAXCHHW = 1:

05250 MAXDSHW = 1:

05260 HTNKAR = 1:

05270 HSUT = 1:

05280 MAXCHCL = 1:

05290 MAXDSCL = 1.5:

05300 CTNKUAA = 0.:

05310 CTNKUAG = 0.:

05320 CTNKAR = 2:

05330 CSUT = 12:

05340 HFUELB = 12250.:

05350 TOTUEF = .294:

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05360 SRATB = 10.3;
05370 RFLASH = .1;
05380 END SPECIAL PARAMETERS;
05390
*****
05400 PART LOADS RATIO;
05410 RECIPROCATING CHILLER (MIN=.02,MAX=1.2,BEST=.65,ELECTRICAL=.3129)
05420 END PART LOADS RATIO;
05430
*****
05440 SCHEDULE;
05450 WEEKDAY HOT TANK CHARGING SCHEDULE = (00 TO 24 - 0);
05460 WEEKEND HOT TANK CHARGING SCHEDULE = (00 TO 24 -0);
05470 WEEKDAY BOILER SCHEDULE = (00 TO 24 - 1);
05480 WEEKEND BOILER SCHEDULE = (00 TO 24 - 1);
05490 HOT TANK CHARGING ON FROM 00 JAN THRU 00 JAN;
05500 WEEKDAY COLD TANK CHARGING SCHEDULE =
05510 (1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,1,1,1,1,1);
05520 WEEKEND COLD TANK CHARGING SCHEDULE =

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```
05530 (1,1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)
05540 WEEKDAY CHILLER SCHEDULE =
05550 (1,1,1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)
05560 WEEKEND CHILLER SCHEDULE =
05570 (1,1,1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)
05580 WEEKDAY RATE SCHEDULE2 =
05590 (2,2,2,2,2,2,2,2,2,2,2,2,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1)
05600 WEEKEND RATE SCHEDULE2 =
05610 (2,2,2,2,2,2,2,2,2,2,2,2,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1)
05620 WEEKDAY RATE SCHEDULE1 =
05630 (4,4,4,4,4,4,4,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3)
05640 WEEKEND RATE SCHEDULE1 =
05650 (4,4,4,4,4,4,4,4,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3)
05660 RATE SCHEDULE2 ON FROM 01 JUN THRU 30 SEP#
05670 CHILLER ON FROM 01 JUN THRU 30 SEP#
05680 BOILER ON FROM 01 OCT THRU 31 MAY#
05690 COLD TANK CHARGING ON FROM 01 JUN THRU 30 SEP#
```

05700 WFEKDAY HOT WATER=(07 TO 17 - 40,17 TO 24 - 7,

05710 24 TO 07 - 0) ;

05720 WFEKFND HOT WATER=(00 TO 24 - 0) ;

05730 END SCHEDULE ;

05740

05750 LIFE CYCLE COST PARAMETERS ;

05760 PROJECT LIFE = 25 ;

05770 UNIT LABOR COST = 19 ;

05780 END LIFE CYCLE COST PARAMETERS ;

05790

05800 ENERGY COST ;

05810 ELECTRICITY ;

05820 ENERGY UNIT = 3.412, UNIT COST = .058

05830 COST ESCALATION FACTOR = 0,

05840 MINIMUM MONTHLY CHARGE = 0,

05850 MINIMUM PEAK LOAD = 0,

05860 DEMAND CHARGE = 0 ,

05870 INFLATION =	7.5%	
05880		*****
05890 BOILER FUEL:		
05900 ENERGY UNIT =	1000	UNIT COST = 7.5%
05910 COST ESCALATION FACTOR =	0.	
05920 MINIMUM MONTHLY CHARGE =	0.	
05930 MINIMUM PEAK LOAD =	0.	
05940 DEMAND CHARGE =	0.	
05950 INFLATION =	7.5%	
05960 END ENERGY COST:		
05970		*****
05980 ACTUAL EQUIPMENT COST:		
05990 BOILER		
06000 SIZE =	1033.	
06010 COST =	.01.	
06020 HOURS TO MAJOR OVERHAUL =	50000.	
06030 MAJOR OVERHAUL COST =	0.	

06040 HOURS TO MINOR OVERHAUL =	15000..
06050 MINOR OVERHAUL COST =	0..
06060 CONSUMABLES =	0..
06070 MAINTENANCE =	0..
06080 LIFE =	100000.†
06090 RECIPROCATING CHILLER	‡
06100 SIZE =	480..
06110 COST =	18000..
06120 HOURS TO MAJOR OVERHAUL =	50000..
06130 MAJOR OVERHAUL COST =	3500..
06140 HOURS TO MINOR OVERHAUL =	15000..
06150 MINOR OVERHAUL COST =	300..
06160 CONSUMABLES =	0..
06170 MAINTENANCE =	0..
06180 LIFE =	100000.†
06190 END ACTUAL EQUIPMENT COST ‡	

06200

06210 OTHER COST PARAMETERS:	
06220 BUILDING CAPITAL COST =	30900.†
06230 ANNUAL BUILDING MAINTENANCE =	0.†
06240 PERIODIC BUILDING COSTS =	0.†
06250 PERIOD =	0.†
06260 FAN SYSTEM CAPITAL COST =	0.†
06270 ANNUAL FAN SYSTEM MAINTENANCE =	0.†
06280 PERIODIC FAN SYSTEM COST =	0.†
06290 PERIOD =	0.†
06300 END OTHER COST PARAMETERS:	
06310 END PLANT:	
06320	*****
06330	*****
06340 PLANT 3 *COLD STORAGE CHILLER 24 HOUR OPERATION "	
06350 SERVING SYSTEM 1,2	;
06360 EQUIPMENT SELECTION:	
06370 1 COLD STORAGE TANK OF SIZE 4000.†	

00380	1 BOILER	OF SIZE	1033.†
00390	1 RECIPROCATING CHILLER	OF SIZE	240.†
00400 END EQUIPMENT SELECTION†			
00410 *****			
00420 SPECIAL PARAMETERS†			
00430	RUNTMB = 1†		
00440	MAXCHN = 1†		
00450	MAXDSH = 1†		
00460	HTNKAR = 1†		
00470	HSDT = 1†		
00480	RUNTMCH = 24†		
00490	MAXCHCL = 1†		
00500	MAXDSC = 2.0†		
00510	CTNKUAA = 0.†		
00520	CTNKUAG = 0.†		
00530	CTNKAR = 2†		
00540	CSUT = 12†		

06550 HFUELB = 12250.†
 06560 TOTUEF = .294†
 06570 SHATB = 10.3†
 06580 RFLASH = .1†
 06590 END SPECIAL PARAMETERS†
 06600

 06610 PART LOADS RATIOS:
 06620 RECIPROCATING CHILLER (MIN=.02,MAX=1.2,BEST=.65,ELECTRICAL=.3129)
 06630 END PART LOAD RATIOS†
 06640

 06650 SCHEDULE:
 06660 WEEKDAY HOT TANK CHARGING SCHEDULE =(00 TO 24 - 0)†
 06670 WEEKEND HOT TANK CHARGING SCHEDULE =(00 TO 24 - 0)†
 06680 WEEKDAY BOILER SCHEDULE = (00 TO 24 - 1)†
 06690 WEEKEND BOILER SCHEDULE = (00 TO 24 - 1)†
 06700 HOT TANK CHARGING ON FROM 00 JAN THRU 00 JAN†
 06710 WEEKDAY COLD TANK CHARGING SCHEDULE =

```
06720 (1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1)
06730 WEEKEND COLD TANK CHARGING SCHEDULE =
06740 (1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1)
06750 WEEKDAY CHILLER SCHEDULE = (OO TO 24 - 1)†
06760 WEEKEND CHILLER SCHEDULE = (OO TO 24 - 1)†
06770 WEEKDAY RATE SCHEDULE2 =
06780 (2,2,2,2,2,2,2,2,2,2,2,2,1,1,1,1,1,1,1,1,1,1,2,2,2,2)
06790 WEEKEND RATE SCHEDULE2 =
06800 (2,2,2,2,2,2,2,2,2,2,2,2,1,1,1,1,1,1,1,1,1,1,2,2,2,2)
06810 WEEKDAY RATE SCHEDULE1 =
06820 (4,4,4,4,4,4,4,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3)
06830 WEEKEND RATE SCHEDULE1 =
06840 (4,4,4,4,4,4,4,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3)
06850 RATE SCHEDULE2 ON FROM 01 JUN THRU 30 SEP†
06860 CHILLER ON FROM 01 JUN THRU 30 SEP†
06870 BOILER ON FROM 01 OCT THRU 31 MAY†
06880 COLD TANK CHARGING ON FROM 01 JUN THRU 30 SEP†
```

06890 WEEKDAY HOT WATER=(07 TO 17 - 40,17 TO 24 - 7,

06900 24 TO 07 - 0) ;

06910 WEEKEND HOT WATER=(00 TO 24 - 0) ;

06920 END SCHEDULE ;

06930

06940 LIFE CYCLE COST PARAMETERS:

06950 PROJECT LIFE = 25 ;

06960 UNIT LABOR COST = 19 ;

06970 END LIFE CYCLE COST PARAMETERS ;

06980

06990 ENERGY COST:

07000 ELECTRICITY:

07010 ENERGY UNIT = 3.412, UNIT COST = .058 ,

07020 COST ESCALATION FACTOR = 0,

07030 MINIMUM MONTHLY CHARGE = 0,

07040 MINIMUM PEAK LOAD = 0,

07050 DEMAND CHARGE = 0 ,

07060 INFLATION =	7.5%	
07070		*****
07080 BOILER FUEL:		
07090 ENERGY UNIT =	1000	UNIT COST = 7.53
07100 COST ESCALATION FACTOR =	0,	
07110 MINIMUM MONTHLY CHARGE =	0,	
07120 MINIMUM PEAK LOAD =	0,	
07130 DEMAND CHARGE =	0,	
07140 INFLATION =	7.5%	
07150 END ENERGY COST:		
07160		*****
07170 ACTUAL EQUIPMENT COST:		
07180 BOILER	:	
07190 SIZE =	1033..	
07200 COST =	.01,	
07210 HOURS TO MAJOR OVERHAUL =	50000..	
07220 MAJOR OVERHAUL COST =	0.,	

07230 HOURS TO MINOR OVERHAUL =	15000..
07240 MINOR OVERHAUL COST =	0..
07250 CONSUMABLES =	0..
07260 MAINTENANCE =	0..
07270 LIFE =	100000..
07280 RECIPROCATING CHILLER	:
07290 SIZE =	240..
07300 COST =	10000..
07310 HOURS TO MAJOR OVERHAUL =	50000..
07320 MAJOR OVERHAUL COST =	2000..
07330 HOURS TO MINOR OVERHAUL =	15000..
07340 MINOR OVERHAUL COST =	250..
07350 CONSUMABLES =	0..
07360 MAINTENANCE =	0..
07370 LIFE =	100000..
07380 END ACTUAL EQUIPMENT COST :	
07390	

07400 OTHER COST PARAMETERS:	
07410 BUILDING CAPITAL COST =	20600.0
07420 ANNUAL BUILDING MAINTENANCE =	0.0
07430 PERIODIC BUILDING COSTS =	0.0
07440 PERIOD =	0.0
07450 FAN SYSTEM CAPITAL COST =	0.0
07460 ANNUAL FAN SYSTEM MAINTENANCE =	0.0
07470 PERIODIC FAN SYSTEM COST =	0.0
07480 PERIOD =	0.0
07490 END OTHER COST PARAMETERS:	
07500 END PLANT:	
07510 END CENTRAL PLANT DESCRIPTION:	
07520 END INPUT:	

APPENDIX B
BLAST INPUT LISTING FOR
BUILDING 20050

00010 *****
 00020 **BUILDING LEAD-IN**
 00030 *****
 00040 ** BUILDING NUMBER = 20050
 00050 ** ENGINEER = MCMULLEN-PAPAPROKOP
 00060 ** AUTOVON PHONE NUMBER = 787-4107
 00070 ** TOTAL REAL PROPERTY AREA OF BUILDING = 52298
 00080 ** PROJECT AREA = 52298
 00090 ** MULTI-PURPOSE BUILDING (B)
 00100 ** FUEL TYPE = COAL
 00110 ** CATCODE = 311173
 00120 ** CAT DESCRIPTION = ACFT RSCH ENG
 00130 ** BASF CASE = EXISTING BUILDING
 00140 ** ALT 1 = COLD STORAGE CHILLER 12HOUR OPERATION
 00150 ** ALT 2 = COLD STORAGE CHILLER 24 HOUR OPERATION
 00160 ** FY 84 BETS PROGRAM
 00170 ** BASE = WRIGHT-PATTERSON

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00180 ** LOCATION = DAYTON, OHIO
00190 ** MAJOR COMMAND = AFLC
00200 ** MAJCOM REVIEWER = _____
00210 **
00220 **
00230 *****
00240 *****
00250 BEGIN INPUT :
00260 RUN CONTROL: NEW ZONFS,NEW AIR SYSTEMS, CENTRAL PLANT,
00270 REPORTS (WALLS, COIL LOADS, SYSTEM, ECIP):
00280 DEFINE LOCATION :
00290 WRIGHT-PATTERSON = (LAT = 39.49, LONG = 84.03,TZ = 5):
00300 END LOCATION :
00310 DEFINE DESIGN DAYS :
00320 WRIGHT-PATTERSON WINTER = (HIGH =25, LOW = 3, WB = 22,
00330 DATE = 21 JAN, PRES = 391, WS =1320, DIR = 225,
00340 CLEARNESS = .95, WEEKDAY).

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00350 WRIGHT-PATTERSON SUMMER = (HIGH = 99, LOW = 72, WB = 80,
00360 DATE = 15 AUG, PRES = 301, WS = 600, DIR = 225,
00370 CLEARNESS = .95, WEEKDAY) ;

00380 END DESIGN DAYS ;

00390 *****
00400 ** TO RUN A FULL YEAR SIMULATION, REMOVE THE "***" FROM IN FRONT OF **
00410 ** WEATHER TAPE AND PUT THEM IN FRONT OF DESIGN DAYS. **
00420 *****
00430 *****
00440 TEMPORARY WALLS :
00450 MYWALL1 = (C10 - 8 IN HW CONCRETE
00460 C13 - 6 IN HW CONCRETE
00470 B1 - AIRSPACE RESISTANCE
00480 F1 - 3/4 IN PLASTER OR GYP BOARD ) ;
00490 END WALLS ;
00500 *****
00510 TEMPORARY WALLS ;

```

00520	MYWALL2 = (A2 - 4 IN DENSE FACE BRICK	.
00530	C8 - 8 IN HW CONCRETE BLOCK	.
00540	E5 - ACOUSTIC TILE	.
00550	B1 - AIRSPACE RESISTANCE	.
00560	INSULATION - GLASS FIBER BONDED 3 IN	.
00570	E1 - 3/4 IN PLASTER OR GYP BOARD) :
00580	END WALLS :	
00590	*****	
00600	TEMPORARY WALLS :	
00610	MYWALL3 = (A2 - 4 IN DENSE FACE BRICK	.
00620	C8 - 8 IN HW CONCRETE BLOCK	.
00630	B1 - AIRSPACE RESISTANCE	.
00640	E1 - 3/4 IN PLASTER OR GYP BOARD) :
00650	END WALLS :	
00660	*****	
00670	TEMPORARY ROOFS :	
00680	MYCEIL1 = (FINISH FLOWING - CORK TILE 1/8 IN	.

00690	C13 - 6 IN HW CONCRETE	.
00700	E4 - CEILING AIRSPACE	.
00710	E5 - ACOUSTIC TILE) :
00720	END ROOFS :	
00730	*****	
00740	TEMPORARY ROOFS :	
00750	MYCEIL2 = (FINISH FLOORING - CARPET FIBROUS PAD	.
00760	C13 - 6 IN HW CONCRETE	.
00770	E4 - CEILING AIRSPACE	.
00780	E5 - ACOUSTIC TILE) :
00790	END ROOFS :	
00800	*****	
00810	TEMPORARY ROOFS :	
00820	MYROOF1 = (ROOFING - BUILT UP ROOFING - 3/8 IN	.
00830	B6 - 2 IN DENSE INSULATION	.
00840	C13 - 6 IN HW CONCRETE	.
00850	E4 - CEILING AIRSPACE	.

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00860                                E5 - ACOUSTIC FILE                                )
00870 END ROOFS :
00880                                *****
00890 TEMPORARY FLOORS :
00900 MYFLOOR1 = (DIRT 12 IN                                .
00910                                C13 - 6 IN HW CONCRETE                                .
00920                                WOOD - HARDWOOD 1 1/2 IN                                .
00930                                FINISH FLOORING - CARPET FIBROUS PAD )
00940 END FLOORS :
00950 TEMPORARY FLOORS :
00960 MYFLOOR2 = (F5 - ACOUSTIC TILE,
00970                                E4 - CEILING AIRSPACE,
00980                                C13 - 6 IN HW CONCRETE,
00990                                FINISH FLOORING - CARPET FIBROUS PAD)
01000 END FLOORS:
01010 PROJECT = "ENERGY ANALYSIS OF BUILDING 20050 "
01020 LOCATION = WRIGHT-PATTERSON :

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01030 ** DESIGN DAYS = WRIGHT-PATTERSON WINTER, WRIGHT-PATTERSON SUMMER

01040 WEATHER TAPE FROM 01 JAN 68 THRU 30 DEC 68 :

01050 GROUND TEMPERATURES = (42,42,46,46,46,63,63,63,59,59,42):

01060 *****

01070 **BUILDING DESCRIPTION**

01080 *****

01090 BEGIN BUILDING DESCRIPTION:

01100 BUILDING = "20050 ACFT RSCH ENG ":

01110 DIMENSIONS: N=0,E=90,W=270,S=180:

01120 NORTH AXIS = 0:

01130 *****

01140 ZONE 1 " BASEMENT LEFT WING "

01150 **

01160 CEILINGS:

01170 FACING (S) MYCEILI (156 RY 52):

01180 **

01190 EXTERIOR WALLS:

01200	FACING (S) MYWALL1	(90.7	BY 9),
01210	FACING (S) MYWALL3	(43	BY 3	) WITH
01220	WINDOWS OF TYPE DOUBLE PANE WINDOW			
01230		(22	BY 3.0	) AT (0.0),
01240	FACING (N) MYWALL1	(132	BY 6),
01250	FACING (N) MYWALL3	(48	BY 3	) WITH
01260	WINDOWS OF TYPE DOUBLE PANE WINDOW			
01270		(16	BY 3	) AT (0.0),
01280	FACING (W) MYWALL1	(52	BY 9	) WITH
01290	WINDOWS OF TYPE DOUBLE PANE WINDOW			
01300		(9.5	BY 3	) AT (0.0) WITH
01310	DOORS OF TYPE SOLID WOOD DOOR			
01320		(6	BY 8	) AT (0.0):
01330				**
01340	PARTITIONS:			
01350	FACING (N) PARTITION23	(40	BY 9) :
01360				**

01370 BASEMENT WALLS:

01380 FACING (N) MYWALL1 (150 BY 3):

01390 FACING (N) MYWALL1 (52 BY 9):

01400 **

01410 SLAB ON GRADE FLOOR:

01420 FACING (E) MYFLOOR1 (156 BY 52):

01430 **

01440 CONTROLS = NIGHT AND WEEKEND SETBACK WITH DUAL THROTTLING RANGES .

01450 137 HEATING, 116 COOLING:

01460 PEOPLE = 12, OFFICE OCCUPANCY :

01470 LIGHTS = 50, OFFICE LIGHTING :

01480 ELECTRIC EQUIPMENT = 40, HOSPITAL OCCUPANCY :

01490 INFILTRATION = 1217, OFFICE LIGHTING :

01500 END:

01510 *****

01520 ZONE 2 " BASEMENT CENTER "

01530 **

01540	CEILINGS:			
01550	FACING (S) MYCEIL	(101	BY 51) :
01560				
			**	
01570	EXTERIOR WALLS:			
01580	FACING (S) MYWALL	(51	BY 9	) WITH
01590	WINDOWS OF TYPE DOUBLE PANE WINDOW			
01600		(8	BY 3	) AT (0,0) WITH
01610	WINDOWS OF TYPE SINGLE PANE HW WINDOW			
01620		(5.7	BY 5	) AT (0,0) WITH
01630	DOORS OF TYPE SOLID WOOD DOOR			
01640		(6	BY 8	) AT (0,0),
01650	FACING (E) MYWALL	(31.3	BY 4),
01660	FACING (E) MYWALL3	(93	BY 3	) WITH
01670	WINDOWS OF TYPE DOUBLE PANE WINDOW			
01680		(25	BY 3	) AT (0,0),
01690	FACING (W) MYWALL	(85	BY 9),
01700	FACING (W) MYWALL3	(48	BY 3	) WITH

01710	WINDOWS OF TYPE DOUBLE PANE WINDOW	
01720	(24 BY 3) AT (0,0):	
01730	**	
01740	PARTITIONS:	
01750	FACING (N) PARTITION23	(40 BY 9):
01760	**	
01770	BASEMENT WALLS:	
01780	FACING (N) MYWALL1	(101 BY 5):
01790	**	
01800	SLAB ON GRADE FLOOR:	
01810	FACING (E) MYFLOOR1	(101 BY 51):
01820	**	
01830	CONTROLS = NIGHT AND WEEKEND SETBACK WITH DUAL THROTTLING RANGES .	
01840	177 HEATING, 150COOLING:	
01850	PEOPLE = 16, OFFICE OCCUPANCY	:
01860	LIGHTS = 44, OFFICE LIGHTING	:
01870	ELECTRIC EQUIPMENT = 11, HOSPITAL OCCUPANCY	:

01880 INFILTRATION = 773. OFFICE LIGHTING ;

01890 END ;

01900 *****

01910 ZONE 3 " FIRST FLOOR LEFT WG " ;

01920 **

01930 CEILINGS :

01940 FACING (S) MYCELL 2 (142 BY 50.5) ;

01950 **

01960 EXTERIOR WALLS :

01970 FACING (S) MYWALL 2 (110 BY 9) WITH

01980 WINDOWS OF TYPE DOUBLE PANE WINDOW

01990 (48 BY 6.6) AT (0,0) ,

02000 FACING (N) MYWALL 2 (142 BY 9) WITH

02010 WINDOWS OF TYPE DOUBLE PANE WINDOW

02020 (56 BY 6.6) AT (0,0) WITH

02030 WINDOWS OF TYPE SINGLE PANE HW WINDOW

02040 (13.8 BY 9) AT (0,0) ,

02050 FACING (W) MYWALL2 (50.5 BY 9) WITH
 02060 WINDOWS OF TYPE DOUBLE PANE WINDOW
 02070 (14.5 BY 6.6) AT (0,0):
 02080 **
 02090 PARTITIONS:
 02100 FACING (N) PARTITION23 (50 BY 9):
 02110 **
 02120 FLOORS:
 02130 FACING (E) MYFLOOR2 (142 BY 50.5):
 02140 **
 02150 CONTROLS = NIGHT AND WEEKEND SETBACK WITH DUAL THROTTLING RANGES .
 02160 324 HEATING, 183COOLING:
 02170 PEOPLE = 22, OFFICE OCCUPANCY :
 02180 LIGHTS = 51, OFFICE LIGHTING :
 02190 ELECTRIC EQUIPMENT = 10, OFFICE LIGHTING :
 02200 INFILTRATION = 1076, OFFICE LIGHTING :
 02210 END:

02220 FACING (E) MYFL00R2 (93 BY 40) :
 02230 **
 02240 CONTROLS = NIGHT AND WEEKEND SETBACK WITH DUAL THROTTLING RANGES ,
 02250 100 HEATING, 51COOLING :
 02260 PEOPLE = 5, OFFICE OCCUPANCY :
 02270 LIGHTS = 13, OFFICE LIGHTING :
 02280 INFILTRATION = 250, OFFICE LIGHTING :
 02290 END :
 02300 *****
 02310 ZONE 5 " SOUTH BASEMENT " :
 02320 **
 02330 CEILINGS :
 02340 FACING (S) MYCELI (96 BY 38.6) :
 02350 **
 02360 EXTERIOR WALLS :
 02370 FACING (W) MYWALLI (96 BY 5.6) WITH
 02380 WINDOWS OF TYPE SINGLE PANE WITH DRAPES

02390 FACING (N) MYWALL2 (122 BY 9) WITH
 02400 WINDOWS OF TYPE DOUBLE PANE WINDOW
 02410 (60 BY 6.6) AT (0,0)†
 02420 **
 02430 PARTITIONS:
 02440 FACING (N) PARTITION23 (40 BY 9)†
 02450 **
 02460 FLOORS:
 02470 FACING (E) MYFLOOR2 (122 BY 50.5)†
 02480 **
 02490 CONTROLS = NIGHT AND WEEKEND SETBACK WITH DUAL THROTTLING RANGES .
 02500 268 HEATING, 151 COOLING†
 02510 PEOPLE = 22, OFFICE OCCUPANCY †
 02520 LIGHTS = 50, OFFICE LIGHTING †
 02530 ELECTRIC EQUIPMENT = 10, OFFICE LIGHTING †
 02540 INFILTRATION = 924, OFFICE LIGHTING †
 02550 END†

02560 *****

02570 ZONE 5 " FIRST FLOOR CENT WG " :

02580 **

02590 CEILINGS:

02600 FACING (S) MYCEIL2 (52 BY 09) :

02610 **

02620 EXTERIOR WALLS:

02630 FACING (S) MYWALL2 (52 BY 8.5) WITH

02640 WINDOWS OF TYPE DOUBLE PANE WINDOW

02650 (22 BY 6.6) AT (0,0).

02660 FACING (E) MYWALL2 (98 BY 8.5) WITH

02670 WINDOWS OF TYPE DOUBLE PANE WINDOW

02680 (48 BY 6.6) AT (0,0).

02690 FACING (W) MYWALL2 (98 BY 8.5) WITH

02700 WINDOWS OF TYPE DOUBLE PANE WINDOW

02710 (57 BY 6.6) AT (0,0) :

02720 **

02730 PARTITIONS:

02740 FACING (N) PARTITION23 (35 BY 8.5):

02750 **

02760 FLOORS:

02770 FACING (E) MYFLOOR2 (52 BY 99):

02780 **

02790 CONTROLS = NIGHT AND WEEKEND SETBACK WITH DUAL THROTTLING RANGES .

02800 287 HEATING, 162COOLING:

02810 PEOPLE = 17, OFFICE OCCUPANCY :

02820 LIGHTS = 36, OFFICE LIGHTING :

02830 ELECTRIC EQUIPMENT = 11, OFFICE LIGHTING :

02840 INFILTRATION = 729, OFFICE LIGHTING :

02850 END:

02860 *****

02870 ZONE 6 " SECOND FLOOR LEFT WG "

02880 **

02890 ROOFS:

02900	STARTING AT (0,0,500) FACING (S)
02910	MYR(X)F1 (137 BY 50.5)†
02920	**
02930	EXTERIOR WALLS:
02940	FACING (S) MYWALL2 (106 BY 9) WITH
02950	WINDOWS OF TYPE DOUBLE PANE WINDOW
02960	(48 BY 6.6) AT (0,0),
02970	FACING (N) MYWALL2 (137 BY 9) WITH
02980	WINDOWS OF TYPE DOUBLE PANE WINDOW
02990	(66 BY 6.6) AT (0,0) WITH
03000	WINDOWS OF TYPE SINGLE PANE HW WINDOW
03010	(13.8 BY 9) AT (0,0),
03020	FACING (W) MYWALL2 (50.5 BY 9) WITH
03030	WINDOWS OF TYPE DOUBLE PANE WINDOW
03040	(14.5 BY 6.6) AT (0,0)†
03050	**
03060	PARTITIONS:

03070 FACING (N) PARTITION23 (55 BY 9) ;
 03080 **
 03090 FLOORS ;
 03100 FACING (E) MYFLOOR2 (137 BY 50.5) ;
 03110 **
 03120 CONTROLS = NIGHT AND WEEKEND SETBACK WITH DUAL THROTTLING RANGES ,
 03130 265 HEATING, 176COOLING ;
 03140 PEOPLE = 22, OFFICE OCCUPANCY ;
 03150 LIGHTS = 50, OFFICE LIGHTING ;
 03160 ELECTRIC EQUIPMENT = 10, OFFICE LIGHTING ;
 03170 INFILTRATION = 1038, OFFICE LIGHTING ;
 03180 END ;
 03190 *****
 03200 ZONE 7 " SECOND FLOOR RIGHT WG " ;
 03210 **
 03220 ROOFS ;
 03230 STARTING AT (0 .0 .500) FACING (S)

03240	MYRORFI	(127	RY 50.5) :
03250		**	
03260	EXTERIOR WALLS:		
03270	FACING (S) MYWALL2	(106	RY 9) WITH
03280	WINDOWS OF TYPE DOUBLE PANE WINDOW		
03290		(59	BY 6.6) AT (0,0),
03300	FACING (E) MYWALL2	(50.5	RY 9) WITH
03310	WINDOWS OF TYPE DOUBLE PANE WINDOW		
03320		(13	RY 6.6) AT (0,0),
03330	FACING (N) MYWALL2	(127	RY 9) :
03340		**	
03350	PARTITIONS:		
03360	FACING (N) PARTITION23	(40	RY 9) :
03370		**	
03380	FLOORS:		
03390	FACING (E) MYFLOOR2	(127	BY 50.5) :
03400		**	

03410 CONTROLS = NIGHT AND WEEKEND SETBACK WITH DUAL THROTTLING PANGES ,
 03420 314 HEATING, 209 COOLING;
 03430 PEOPLE = 22, OFFICE OCCUPANCY ;
 03440 LIGHTS = 38, OFFICE LIGHTING ;
 03450 ELECTRIC EQUIPMENT = 10, OFFICE LIGHTING ;
 03460 INFILTRATION = 962, OFFICE LIGHTING ;
 03470 END;
 03480 *****
 03490 ZONE 8 " SECOND FLOOR CENTRAL WG " ;
 03500 **
 03510 ROOFS;
 03520 STARTING AT (0 ,0 ,500) FACING (S)
 03530 MYROOF1 (52 BY 99) ;
 03540 **
 03550 EXTERIOR WALLS;
 03560 FACING (S) MYWALL2 (52 BY 8.5) WITH
 03570 WINDOWS OF TYPE DOUBLE PANE WINDOW

03580	(22 BY 6.6) AT (0,0),
03590	FACING (E) MYWALL2 (99 BY 8.5) WITH
03600	WINDOWS OF TYPE DOUBLE PANE WINDOW
03610	(48 BY 6.6) AT (0,0),
03620	FACING (W) MYWALL2 (99 BY 8.5) WITH
03630	WINDOWS OF TYPE DOUBLE PANE WINDOW
03640	(57 BY 6.6) AT (0,0):
03650	**
03660	PARTITIONS:
03670	FACING (N) PARTITION23 (35 BY 8.5):
03680	**
03690	FLOORS:
03700	FACING (E) MYFLOOR2 (52 BY 99):
03710	**
03720	CONTROLS = NIGHT AND WEEKEND SETBACK WITH DUAL THROTTLING RANGES .
03730	335 HEATING, 221 COOLING:
03740	PEOPLE = 17, OFFICE OCCUPANCY :

```

03750 LIGHTS =      40, OFFICE LIGHTING      ;
03760 ELECTRIC EQUIPMENT =      11, OFFICE LIGHTING      ;
03770 INFILTRATION =      729, OFFICE LIGHTING      ;
03780 END;
03790 *****
03800 END BUILDING DESCRIPTION;
03810 *****
03820 **
03830 *****
03840 *****
03850 *****
03860 *****
03870 BEGIN FAN SYSTEM DESCRIPTION;
03880 ** SYSTEM 1
03890 MULTIZONE SYSTEM      1" MULTIZONE FAN SYSTEM)
03900 SERVING ZONES 1, 2
03910 *****

```

```

03920 FOR ZONE 1:
03930 SUPPLY AIR VOLUME = 3945.8
03940 EXHAUST AIR VOLUME = 0
03950 END
03960
*****
03970 FOR ZONE 2:
03980 SUPPLY AIR VOLUME = 4910.8
03990 EXHAUST AIR VOLUME = 0
04000 END
04010
*****
04020 OTHER SYSTEM PARAMETERS:
04030 HEATING COIL CAPACITY = 3412000
04040 HEATING COIL ENERGY SUPPLY = STEAM
04050 SUPPLY FAN PRESSURE = 2.0
04060 EXHAUST FAN PRESSURE = 1
04070 RETURN FAN PRESSURE = 0.0
04080 SUPPLY FAN EFFICIENCY = .7

```

04090 EXHAUST FAN EFFICIENCY =	.7	:
04100 RETURN FAN EFFICIENCY =	.7	:
04110 COLD DECK CONTROL =	FIXED SET POINT	:
04120 COLD DECK TEMPERATURE =	55	:
04130 COLD DECK THROTTLING RANGE =	10	:
04140 HOT DECK CONTROL =	OUTSIDE AIR CONTROLLED	:
04150 HOT DECK THROTTLING RANGE =	10	:
04160 HOT DECK CONTROL SCHEDULE =	(140 AT 0, 70 AT 70)	:
04170 WEEKDAY MINIMUM OUTSIDE AIR SCHEDULE =	(00 TO 24-.1)	:
04180 WEEKDAY MAXIMUM OUTSIDE AIR SCHEDULE =	(00 TO 24-.1)	:
04190 WEEKEND MINIMUM OUTSIDE AIR SCHEDULE =	(00 TO 24-.1)	:
04200 WEEKEND MAXIMUM OUTSIDE AIR SCHEDULE =	(00 TO 24-.1)	:
04210 MIXED AIR CONTROL =	FIXED PERCENT	:
04220 **PREHEAT COIL LOCATION =	NONE	:
04230 **PREHEAT TEMPERATURE =	46.4	:
04240 GAS BURNER EFFICIENCY =	.7	:
04250 **PREHEAT ENERGY SUPPLY =	HOT WATER	:

04200	**PREHEAT COIL CAPACITY =	0.0	:
04270	**HUMIDIFIER TYPE =	NONE	:
04280	END OTHER SYSTEM PARAMETERS:		
04290			

04300	COOLING COIL DESIGN PARAMETERS:		
04310	COIL TYPE =	CHILLED WATER	:
04320	AIR VOLUME FLOW RATE =	8855.	:
04330	BAROMETRIC PRESSURE =	397	:
04340	AIR FACE VELOCITY =	490	:
04350	ENTERING AIR DRY BULB TEMPERATURE =	85	:
04360	ENTERING AIR WET BULB TEMPERATURE =	64	:
04370	LEAVING AIR DRY BULB TEMPERATURE =	55	:
04380	LEAVING AIR WET BULB TEMPERATURE =	52.7	:
04390	ENTERING WATER TEMPERATURE =	45	:
04400	LEAVING WATER TEMPERATURE =	55	:
04410	WATER VELOCITY =	275	:
04420	WATER VOLUME FLOW RATE =	7.	:

04430 END COOLING COIL DESIGN PARAMETERS;

04440

04450 EQUIPMENT SCHEDULES;

04460 SYSTEM OPERATION =

INTERMITTENT

;

04470 WEEKDAY SYSTEM SCHEDULE =

(00 TO 24 - ON

) ;

04480 WEEKEND SYSTEM SCHEDULE =

(00 TO 24 - OFF

) ;

04490 WEEKDAY HEATING SCHEDULE =

(00 TO 24-ON)

;

04500 WEEKEND HEATING SCHEDULE =

(00 TO 24-ON)

;

04510 WEEKDAY COOLING SCHEDULE =

(00 TO 24-ON)

;

04520 WEEKEND COOLING SCHEDULE =

(00 TO 24-ON)

;

04530 HEATING CAPACITY ON FROM 01 OCT

THRU 31 MAY ;

04540 COOLING CAPACITY ON FROM 01 JUN

THRU 30 SEP ;

04550 END EQUIPMENT SCHEDULES;

04560 END SYSTEM;

04570

04580

04590 ** SYSTEM 2

04600 MULTIZONE FAN SYSTEM 2 "

;

04610 SERVING ZONES 3, 4, 5

04620

04630 FOR ZONE 3:

04640 SUPPLY AIR VOLUME = 5960.†

04650 EXHAUST AIR VOLUME = 0 ;

04660 END;

04670

04680 FOR ZONE 4:

04690 SUPPLY AIR VOLUME = 4950.†

04700 EXHAUST AIR VOLUME = 0 ;

04710 END;

04720

04730 FOR ZONE 5:

04740 SUPPLY AIR VOLUME = 5280.†

04750 EXHAUST AIR VOLUME = 0 ;

04760 END;

04770

04780 OTHER SYSTEM PARAMETERS:

04790 HEATING COIL CAPACITY =

3412000

04800 HEATING COIL ENERGY SUPPLY =

STEAM

04810 SUPPLY FAN PRESSURE =

2.0

04820 EXHAUST FAN PRESSURE =

1

04830 RETURN FAN PRESSURE =

0.0

04840 SUPPLY FAN EFFICIENCY =

.7

04850 EXHAUST FAN EFFICIENCY =

.7

04860 RETURN FAN EFFICIENCY =

.7

04870 COLD DECK CONTROL =

FIXED SET POINT

04880 COLD DECK TEMPERATURE =

55

04890 COLD DECK THROTTLING RANGE =

10

04900 HOT DECK CONTROL =

OUTSIDE AIR CONTROLLED

04910 HOT DECK THROTTLING RANGE =

10

04920 HOT DECK CONTROL SCHEDULE =

(140 AT 0, 70 AT 70)

04930 WEEKDAY MINIMUM OUTSIDE AIR SCHEDULE = (00 TO 24-.1)

04940	WEEKDAY MAXIMUM OUTSIDE AIR SCHEDULE =	(00 TO 24-.1)	:
04950	WEEKEND MINIMUM OUTSIDE AIR SCHEDULE =	(00 TO 24-.1)	:
04960	WEEKEND MAXIMUM OUTSIDE AIR SCHEDULE =	(00 TO 24-.1)	:
04970	MIXED AIR CONTROL =	FIXED PERCENT	:
04980	**PREHEAT COIL LOCATION =	NONE	:
04990	**PREHEAT TEMPERATURE =	46.4	:
05000	GAS BURNER EFFICIENCY =	.7	:
05010	**PREHEAT ENERGY SUPPLY =	HOT WATER	:
05020	**PREHEAT COIL CAPACITY =	0.0	:
05030	**HUMIDIFIER TYPE =	NONE	:
05040	END OTHER SYSTEM PARAMETERS:		
05050		*****	
05060	COOLING COIL DESIGN PARAMETERS:		
05070	COIL TYPE =	CHILLED WATER	:
05080	AIR VOLUME FLOW RATE =	16190.	:
05090	BAROMETRIC PRESSURE =	397	:
05100	AIR FACE VELOCITY =	490	:

05110 ENTERING AIR DRY BULB TEMPERATURE =	85	:
05120 ENTERING AIR WET BULB TEMPERATURE =	64	:
05130 LEAVING AIR DRY BULB TEMPERATURE =	55	:
05140 LEAVING AIR WET BULB TEMPERATURE =	52.7	:
05150 ENTERING WATER TEMPERATURE =	45	:
05160 LEAVING WATER TEMPERATURE =	55	:
05170 WATER VELOCITY =	275	:
05180 WATER VOLUME FLOW RATE =	13.	:

05190 END COOLING COIL DESIGN PARAMETERS:

05200

05210 EQUIPMENT SCHEDULES:

05220 SYSTEM OPERATION =	INTERMITTENT	:
05230 WEEKDAY SYSTEM SCHEDULE =	(00 TO 24 - ON) :
05240 WEEKEND SYSTEM SCHEDULE =	(00 TO 24 - OFF) :
05250 WEEKDAY HEATING SCHEDULE =	(00 TO 24-ON)	:
05260 WEEKEND HEATING SCHEDULE =	(00 TO 24-ON)	:
05270 WEEKDAY COOLING SCHEDULE =	(00 TO 24-ON)	:

```

05280 WEEKEND COOLING SCHEDULE =          (00 TO 24-0N)      ;
05290 HEATING CAPACITY ON FROM 01 OCT      THRU 31 MAY      ;
05300 COOLING CAPACITY ON FROM 01 JUN      THRU 30 SEP      ;
05310 END EQUIPMENT SCHEDULES;
05320 END SYSTEM;
05330                                     *****
05340                                     *****
05350 ** SYSTEM 3
05360 MULTIZONE SYSTEM                      3" MULTIZONE FAN SYSTEM 3
05370 SERVING ZONES 6, 7, 8                ;
05380                                     *****
05390 FOR ZONE 6;
05400 SUPPLY AIR VOLUME = 5735.1
05410 EXHAUST AIR VOLUME = 0                ;
05420 END;
05430                                     *****
05440 FOR ZONE 7;

```

05450 SUPPLY AIR VOLUME = 6810.1

05460 EXHAUST AIR VOLUME = 0 ;

05470 END ;

05480

05490 FOR ZONE 8 ;

05500 SUPPLY AIR VOLUME = 7230.1

05510 EXHAUST AIR VOLUME = 0 ;

05520 END ;

05530

05540 OTHER SYSTEM PARAMETERS ;

05550 HEATING COIL CAPACITY =

3412000

05560 HEATING COIL ENERGY SUPPLY =

STFAM

05570 SUPPLY FAN PRESSURE =

2.0

05580 EXHAUST FAN PRESSURE =

1

05590 RETURN FAN PRESSURE =

0.0

05600 SUPPLY FAN EFFICIENCY =

.7

05610 EXHAUST FAN EFFICIENCY =

.7

05020	RETURN FAN EFFICIENCY =	.7	:
05030	COLD DECK CONTROL =	FIXED SET POINT	:
05040	COLD DECK TEMPERATURE =	55	:
05050	COLD DECK THROTTLING RANGE =	10	:
05060	HOT DECK CONTROL =	OUTSIDE AIR CONTROLLED	:
05070	HOT DECK THROTTLING RANGE =	10	:
05080	HOT DECK CONTROL SCHEDULE =	(140 AT 0, 70 AT 70)	:
05090	WEEKDAY MINIMUM OUTSIDE AIR SCHEDULE =	(00 TO 24-.1)	:
05700	WEEKDAY MAXIMUM OUTSIDE AIR SCHEDULE =	(00 TO 24-.1)	:
05710	WEEKEND MINIMUM OUTSIDE AIR SCHEDULE =	(00 TO 24-.1)	:
05720	WEEKEND MAXIMUM OUTSIDE AIR SCHEDULE =	(00 TO 24-.1)	:
05730	MIXED AIR CONTROL =	FIXED PERCENT	:
05740	**PREHEAT COIL LOCATION =	NONE	:
05750	**PREHEAT TEMPERATURE =	46.4	:
05760	GAS BURNER EFFICIENCY =	.7	:
05770	**PREHEAT ENERGY SUPPLY =	HOT WATER	:
05780	**PREHEAT COIL CAPACITY =	0.0	:

05790	**HUMIDIFIER TYPE =	NONE	:
05800	END OTHER SYSTEM PARAMETERS:		
05810		*****	
05820	COOLING COIL DESIGN PARAMETERS:		
05830	COIL TYPE =	CHILLED WATER	:
05840	AIR VOLUME FLOW RATE =	19775.	:
05850	BAROMETRIC PRESSURE =	397	:
05860	AIR FACE VELOCITY =	490	:
05870	ENTERING AIR DRY BULB TEMPERATURE =	85	:
05880	ENTERING AIR WET BULB TEMPERATURE =	64	:
05890	LEAVING AIR DRY BULB TEMPERATURE =	55	:
05900	LEAVING AIR WET BULB TEMPERATURE =	52.7	:
05910	ENTERING WATER TEMPERATURE =	45	:
05920	LEAVING WATER TEMPERATURE =	55	:
05930	WATER VELOCITY =	275	:
05940	WATER VOLUME FLOW RATE =	10.	:
05950	END COOLING COIL DESIGN PARAMETERS:		

05960

05970 EQUIPMENT SCHEDULES:

05980 SYSTEM OPERATION =

INTERMITTENT

:

05990 WEEKDAY SYSTEM SCHEDULE =

(00 TO 24 - ON

) :

06000 WEEKEND SYSTEM SCHEDULE =

(00 TO 24 - OFF

) :

06010 WEEKDAY HEATING SCHEDULE =

(00 TO 24-ON)

:

06020 WEEKEND HEATING SCHEDULE =

(00 TO 24-ON)

:

06030 WEEKDAY COOLING SCHEDULE =

(00 TO 24-ON)

:

06040 WEEKEND COOLING SCHEDULE =

(00 TO 24-ON)

:

06050 HEATING CAPACITY ON FROM 01 OCT

THRU 31 MAY :

06060 COOLING CAPACITY ON FROM 01 JUN

THRU 30 SEP :

06070 END EQUIPMENT SCHEDULES:

06080 END SYSTEM:

06090

06100

06110 END FAN SYSTEM DESCRIPTION:

06120 BEGIN CENTRAL PLANT DESCRIPTION:

06130

06140

06150 ECIP PARAMETERS:

06160 BUILDING AREA = 52298;

06170 MAJCOM = "AFLC";

06180 BUILDING NUMBER = "20050";

06190 AIR FORCE BASE = "WRIGHT-PATTERSON";

06200 USE = "ACFT RSCH ENG";

06210 FUEL TYPE = "COAL";

06220 END ECIP;

06230 PLANT 1 "CENTRAL PLANT SYSTEM 1

06240 SERVING SYSTEM 1,2,3

06250 EQUIPMENT SELECTION:

06260 1 BOILER

OF SIZE 1200.;

06270 1 RECIPROCATING CHILLER

OF SIZE 1440.;

06280 END EQUIPMENT SELECTION;

06290

00300 SPECIAL PARAMETERS:

06310 HFUEL B = 12250.†

00320 TOTUEF = .294†

06330 SHATB = 10.3†

06340 RFLASH = .1†

06350 END SPECIAL PARAMETERS†

06360

06370 PART LOADS RATIO:

06380 RECIPROCATING CHILLER (MIN=.02, MAX=1.2, BEST=.65, ELECTRICAL=.3129)

06390 END PART LOAD RATIOS†

06400

06410 SCHEDULE:

00420 WEEKDAY RATE SCHEDULE2 =

06430 (2,2,2,2,2,2,2,2,2,2,2,2,1,1,1,1,1,1,1,1,1,1,2,2,2,2)†

00440 WEEKEND RATE SCHEDULE2 =

06450 (2,2,2,2,2,2,2,2,2,2,2,2,1,1,1,1,1,1,1,1,1,1,2,2,2,2)†

00460 WEEKDAY RATE SCHEDULE1 =

06640 COST ESCALATION FACTOR = 0.
 06650 MINIMUM MONTHLY CHARGE = 0.
 06660 MINIMUM PEAK LOAD = 0.
 06670 DEMAND CHARGE = 0 ,

06680 INFLATION = 7.5%

06690

06700 BOILER FUEL :

06710 ENERGY UNIT = 1000 , UNIT COST = 7.53 ,

06720 COST ESCALATION FACTOR = 0.

06730 MINIMUM MONTHLY CHARGE = 0.

06740 MINIMUM PEAK LOAD = 0.

06750 DEMAND CHARGE = 0.

06760 INFLATION = 7.5%

06770 END ENERGY COST :

06780

06790 ACTUAL EQUIPMENT COST :

06800 BOILER :

06810 SIZE =	1200..
06820 COST =	.01,
06830 HOURS TO MAJOR OVERHAUL =	50000..
06840 MAJOR OVERHAUL COST =	0..
06850 HOURS TO MINOR OVERHAUL =	15000..
06860 MINOR OVERHAUL COST =	0..
06870 CONSUMABLES =	0..
06880 MAINTENANCE =	0..
06890 LIFE =	100000..
06900 RECIPROCATING CHILLER :	
06910 SIZE =	1440..
06920 COST =	40000..
06930 HOURS TO MAJOR OVERHAUL =	50000..
06940 MAJOR OVERHAUL COST =	7800..
06950 HOURS TO MINOR OVERHAUL =	15000..
06960 MINOR OVERHAUL COST =	500..
06970 CONSUMABLES =	0..

06980 MAINTENANCE =	0..	
06990 LIFE =	100000.0	
07000 END ACTUAL EQUIPMENT COST:		
07010		*****
07020 OTHER COST PARAMETERS:		
07030 BUILDING CAPITAL COST =		0.0
07040 ANNUAL BUILDING MAINTENANCE =		0.0
07050 PERIODIC BUILDING COSTS =		0.0
07060 PERIOD =		0.0
07070 FAN SYSTEM CAPITAL COST =		0.0
07080 ANNUAL FAN SYSTEM MAINTENANCE =		0.0
07090 PERIODIC FAN SYSTEM COST =		0.0
07100 PERIOD =		0.0
07110 END OTHER COST PARAMETERS:		
07120 END PLANT:		
07130		*****
07140		*****

07150 PLANT 2 "COLD STORAGE CHILLER 12 HOUR OPERATION " ;

07160 SERVING SYSTEM 1,2,3 ;

07170 EQUIPMENT SELECTION:

07180 1 COLD STORAGE TANK OF SIZE 17000. ;

07190 1 BOILER OF SIZE 1200. ;

07200 1 RECIPROCATING CHILLER OF SIZE 1440. ;

07210 END EQUIPMENT SELECTION;

07220 *****

07230 SPECIAL PARAMETERS:

07240 RUNTMB = 1 ;

07250 MAXCHHW = 1 ;

07260 MAXDSHW = 1 ;

07270 HTNKAR = 1 ;

07280 HSDT=1 ;

07290 RUNTMCH = 12 ;

07300 MAXCHCL = 1 ;

07310 MAXDSCL = 1.5 ;

07320 CTNKUAA = 0.†
 07330 CTNKUAG = 0.†
 07340 CTNKAR = 2†
 07350 CSDT = 12.†
 07360 HFUEL B = 12250.†
 07370 TOTUEF = .294†
 07380 SKATB = 10.3†
 07390 RFLASH = .1†
 07400 END SPECIAL PARAMETERS†
 07410 *****
 07420 PART LOADS RATIO†
 07430 RECIPROCATING CHILLER (MIN=.02, MAX=1.2, BEST=.65, ELECTRICAL=.3129)
 07440 END PART LOADS RATIO†
 07450 *****
 07460 SCHEDULE†
 07470 WEEKDAY HOT TANK CHARGING SCHEDULE =(00 TO 24 - 0)†
 07480 WEEKEND HOT TANK CHARGING SCHEDULE =(00 TO 24 - 0)†

07490 WEEKDAY BOILER SCHEDULE = (00 TO 24 - 1):
 07500 WEEKEND BOILER SCHEDULE = (00 TO 24 - 1):
 07510 HOT TANK CHARGING ON FROM 00 JAN THRU 00 JAN:
 07520 WEEKDAY COLD TANK CHARGING SCHEDULE =
 07530 (1,1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,1,1,1,1,1):
 07540 WEEKEND COLD TANK CHARGING SCHEDULE =
 07550 (1,1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,1,1,1,1,1):
 07560 WEEKDAY CHILLER SCHEDULE =
 07570 (1,1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,1,1,1,1,1):
 07580 WEEKEND CHILLER SCHEDULE =
 07590 (1,1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,1,1,1,1,1):
 07600 WEEKDAY RATE SCHEDULE 2 =
 07610 (2,2,2,2,2,2,2,2,2,2,2,1,1,1,1,1,1,1,1,2,2,2):
 07620 WEEKEND RATE SCHEDULE 2 =
 07630 (2,2,2,2,2,2,2,2,2,2,2,1,1,1,1,1,1,1,1,2,2,2):
 07640 WEEKDAY RATE SCHEDULE 1 =
 07650 (4,4,4,4,4,4,4,3,3,3,3,3,3,3,3,3,3,3,3,4,4,4):

[illegible]

07080 RATE SCHEDULE2 ON FROM 01 JUN THRU 30 SEP:

07090 CHILLER ON FROM 01 JUN THRU 30 SEP;

07700 BOILER ON FROM 01 OCT THRU 31 MAY:

07710 COLD TANK CHARGING ON FROM 01 JUN THRU 30 SEP;

07720 WEEKDAY HOT WATER=(07 TO 17 - 40, 17 TO 24 - 7,

07/30 24 TO 07 - 0 18

07740 WFEKEND HOT WATER=(00 TO 24 - 0):

07150 END SCHEDULE:

09160

07770 LIFE CYCLE COST PARAMETERS:

07780 PROJECT LIFE = 25

07790 UNIT LABOR COST = 19

07800 FND LFF CYCLF COST PARAMETERS:

07810

07420 ENERGY COST:

07830 ELECTRICITY:

07840 ENERGY UNIT = 3.412, UNIT COST = .058 ,

07850 COST ESCALATION FACTOR = 0,

07860 MINIMUM MONTHLY CHARGE = 0,

07870 MINIMUM PEAK LOAD = 0,

07880 DEMAND CHARGE = 0 ,

07890 INFLATION = 7.5%

07900

07910 BOILER FUEL:

07920 ENERGY UNIT = 1000 , UNIT COST = 7.53 ,

07930 COST ESCALATION FACTOR = 0,

07940 MINIMUM MONTHLY CHARGE = 0,

07950 MINIMUM PEAK LOAD = 0,

07960 DEMAND CHARGE = 0,

07970 INFLATION = 7.5%

07980 END ENERGY COST:

07990

08000 ACTUAL EQUIPMENT COST :

08010	BOILER	:	
08020	SIZE =		1200..
08030	COST =		.01.
08040	HOURS TO MAJOR OVERHAUL =		50000..
08050	MAJOR OVERHAUL COST =		0..
08060	HOURS TO MINOR OVERHAUL =		15000..
08070	MINOR OVERHAUL COST =		0..
08080	CONSUMABLES =		0..
08090	MAINTENANCE =		0..
08100	LIFE =		100000..
08110	RECIPROCATING CHILLER	:	
08120	SIZE =		1440..
08130	COST =		40000..
08140	HOURS TO MAJOR OVERHAUL =		50000..
08150	MAJOR OVERHAUL COST =		7800..
08160	HOURS TO MINOR OVERHAUL =		15000..

08170 MINOR OVERHAUL COST =	5000.0
08180 CONSUMABLES =	0.0
08190 MAINTENANCE =	0.0
08200 LIFE =	100000.0
08210 END ACTUAL EQUIPMENT COST:	
08220	*****
08230 OTHER COST PARAMETERS:	
08240 BUILDING CAPITAL COST =	87925.0
08250 ANNUAL BUILDING MAINTENANCE =	0.0
08260 PERIODIC BUILDING COSTS =	0.0
08270 PERIOD =	0.0
08280 FAN SYSTEM CAPITAL COST =	0.0
08290 ANNUAL FAN SYSTEM MAINTENANCE =	0.0
08300 PERIODIC FAN SYSTEM COST =	0.0
08310 PERIOD =	0.0
08320 END OTHER COST PARAMETERS:	
08330 END PLANT:	

08340

08350

08360 PLANT 3 "COLD STORAGE CHILLER 24 HOUR OPERATION "

08370 SERVING SYSTEM 1,2,3

08380 EQUIPMENT SELECTION:

08390 1 COLD STORAGE TANK OF SIZE 11000:

08400 1 BOILER OF SIZE 1200.:

08410 1 RECIPROCATING CHILLER OF SIZE 720.:

08420 END EQUIPMENT SELECTION:

08430

08440 SPECIAL PARAMETERS:

08450 RUNTMB =1:

08460 MAXCHHW =1:

08470 MAXDSHW =1:

08480 HTNKAR =1:

08490 HSOT =1:

08500 RUNTMCH = 24:

08510 MAXCHCL = 1;
 08520 MAXDSCL = 2.0;
 08530 CTNKUAA = 0.1;
 08540 CTNKUAG = 0.1;
 08550 CTNKAR = 2;
 08560 CSDT = 12;
 08570 HFUELH = 12250.1;
 08580 TORUEF = .294;
 08590 SHATB = 10.3;
 08600 RFLASH = .1;
 08610 END SPECIAL PARAMETERS;
 08620 *****
 08630 PART LOADS RATIO;
 08640 RECIPROCATING CHILLER (MIN=.02, MAX=1.2, REST=.05, ELECTRICAL=.3125)
 08650 END PART LOAD RATIOS;
 08660 *****
 08670 SCHEDULE;

08680 WEEKDAY HOT TANK CHARGING SCHEDULE =(00 TO 24 - 0):
 08690 WEEKEND HOT TANK CHARGING SCHEDULE =(00 TO 24 - 0):
 08700 WEEKDAY BOILER SCHEDULE =(00 TO 24 - 1):
 08710 WEEKEND BOILER SCHEDULE =(00 TO 24 - 1):
 08720 HOT TANK CHARGING ON FROM 00 JAN THRU 00 JAN:
 08730 WEEKDAY COLD TANK CHARGING SCHEDULE =
 08740 (1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1):
 08750 WEEKEND COLD TANK CHARGING SCHEDULE =
 08760 (1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1):
 08770 WEEKDAY CHILLER SCHEDULE = (00 TO 24 - 1):
 08780 WEEKEND CHILLER SCHEDULE = (00 TO 24 - 1):
 08790 WEEKDAY RATE SCHEDULE2 =
 08800 (2,2,2,2,2,2,2,2,2,2,1,1,1,1,1,1,1,1,1,2,2,2):
 08810 WEEKEND RATE SCHEDULE2 =
 08820 (2,2,2,2,2,2,2,2,2,2,1,1,1,1,1,1,1,1,1,2,2,2):
 08830 WEEKDAY RATE SCHEDULE1 =
 08840 (4,4,4,4,4,4,4,4,3,3,3,3,3,3,3,3,3,3,3,4,4,4):

09020 ELECTRICITY:

09030 ENERGY UNIT = 3.412, UNIT COST = .058 ,

09040 COST ESCALATION FACTOR = 0,

09050 MINIMUM MONTHLY CHARGE = 0,

09060 MINIMUM PEAK LOAD = 0,

09070 DEMAND CHARGE = 0 ,

09080 INFLATION = 7.5%

09090

09100 BOILER FUEL:

09110 ENERGY UNIT = 1000 , UNIT COST = 7.53 ,

09120 COST ESCALATION FACTOR = 0,

09130 MINIMUM MONTHLY CHARGE = 0,

09140 MINIMUM PEAK LOAD = 0,

09150 DEMAND CHARGE = 0,

09160 INFLATION = 7.5%

09170 END ENERGY COST:

09180

09190 ACTUAL EQUIPMENT COST:

09200	BOILER	:	
09210	SIZE =		1200..
09220	COST =		.01.
09230	HOURS TO MAJOR OVERHAUL =		50000..
09240	MAJOR OVERHAUL COST =		0..
09250	HOURS TO MINOR OVERHAUL =		15000..
09260	MINOR OVERHAUL COST =		0..
09270	CONSUMABLES =		0..
09280	MAINTENANCE =		0..
09290	LIFE =		100000.:
09300	RECIPROCATING CHILLER	:	
09310	SIZE =		720..
09320	COST =		22000..
09330	HOURS TO MAJOR OVERHAUL =		50000..
09340	MAJOR OVERHAUL COST =		5000..
09350	HOURS TO MINOR OVERHAUL =		15000..

09360 MINOR OVERHAUL COST =	350.0
09370 CONSUMABLES =	0.0
09380 MAINTENANCE =	0.0
09390 LIFE =	100000.0
09400 END ACTUAL EQUIPMENT COST:	
09410	

09420 OTHER COST PARAMETERS:	
09430 BUILDING CAPITAL COST =	56900.0
09440 ANNUAL BUILDING MAINTENANCE =	0.0
09450 PERIODIC BUILDING COSTS =	0.0
09460 PERIOD =	0.0
09470 FAN SYSTEM CAPITAL COST =	0.0
09480 ANNUAL FAN SYSTEM MAINTENANCE =	0.0
09490 PERIODIC FAN SYSTEM COST =	0.0
09500 PERIOD =	0.0
09510 END OTHER COST PARAMETERS:	
09520 END PLANT:	

09530 END CENTRAL PLANT DESCRIPTION;

09540 END INPUT;

APPENDIX C
BLAST OUTPUT REPORTS FOR
BUILDING 20040

2040 MEDICAL DISPEN

CENTRAL BUILDING UNIT

LOADS SUMMARY FOR ZONE 13

MAJOR PATIENTS ON A F B

MO	DAY	HR	HEATING LOAD (BTU)	Cooling LOAD (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	BASEBOARD LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILT HEAT LOSS (BTU)	INFILT HEAT GAIN (BTU)	MAT/ H EX H	IMB/ C IN C	EX
1			6.670E+07	0.	4.220E+05	0.	0.	2.310E+07	0.	2.704E+07	0.	0	743	0
2			5.442E+07	0.	3.863E+05	0.	0.	2.109E+07	0.	2.225E+07	0.	0	687	0
3			2.325E+07	1.421E+06	4.573E+05	0.	0.	2.219E+07	0.	1.129E+07	2.942E+03	0	514	37
4			1.645E+06	3.533E+06	5.706E+05	0.	0.	2.301E+07	0.	2.115E+06	0.	0	91	107
5			5.990E+04	8.291E+06	6.283E+05	0.	0.	2.310E+07	0.	2.222E+05	3.291E+04	0	6	181
6			0.	2.159E+07	6.112E+05	0.	0.	2.117E+07	0.	0.	5.021E+05	0	0	200
7			0.	2.782E+07	6.780E+05	0.	0.	2.310E+07	0.	0.	1.135E+06	0	0	220
8			0.	2.512E+07	6.740E+05	0.	0.	2.310E+07	0.	0.	8.929E+05	0	0	220
9			0.	1.154E+07	5.926E+05	0.	0.	2.117E+07	0.	0.	4.640E+04	0	0	185
10			4.778E+06	4.125E+06	5.320E+05	0.	0.	2.219E+07	0.	2.650E+06	3.741E+04	0	206	101
11			2.214E+07	2.389E+05	4.040E+05	0.	0.	2.117E+07	0.	1.125E+07	0.	0	603	10
12			5.470E+07	0.	3.660E+05	0.	0.	2.117E+07	0.	2.075E+07	0.	0	719	0
<hr/>														
FINAL			2.279E+08	1.037E+08	6.346E+06	0.	0.	2.656E+08	0.	9.759E+07	2.650E+06	0	3569	1261

MAXIMUM HEATING LOAD = 3.309E+05 AT HOUR 8 ON DAY 8 OF MONTH 1 WITH A ZONE AIR TEMP OF 67.53
 MAXIMUM COOLING LOAD = 1.961E+05 AT HOUR 15 ON DAY 18 OF MONTH 7 WITH A ZONE AIR TEMP OF 74.59
 MAXIMUM ZONE AIR TEMP = 1.046E+02 AT HOUR 16 ON DAY 21 OF MONTH 7
 MINIMUM ZONE AIR TEMP = 6.133E+01 AT HOUR 7 ON DAY 8 OF MONTH 1

DEFILATION HEAT GAIN/LOSS REFERS TO SENSIBLE PORTION ONLY.
 LATENT PORTION IS COMPUTED BY AIR HANDLING SYSTEM SUBPROGRAM.
 LOSS = MASS FLOW * SPECIFIC HEAT * (ZONE TEMP - OUTSIDE TEMP)
 IT IS INCLUDED IN TOTAL SENSIBLE LOAD.

LOADS SUMMARY FOR ZONE		2X	RIGHT BUILDING UNIT			20040 MEDICAL DISPEN							
NIGHT PATTERN A F B			HEATING	Cooling	Latent	Return Air	Baseboard	Electric	Gas	Infilt	Infilt	Nat/	IMB/
MO	DAY	HR	LOAD	LOAD	LOAD	HEAT GAIN	LOAD	LOAD	LOAD	HEAT LOSS	HEAT GAIN	HEX	CM
			(BTU)	(BTU)	(BTU)	(BTU)	(BTU)	(BTU)	(BTU)	(BTU)	(BTU)	H	C
1			2.704E+07	0.	4.239E+05	0.	0.	1.152E+07	0.	1.046E+07	0.	0	0
2			2.226E+07	0.	3.886E+05	0.	0.	1.052E+07	0.	8.904E+06	0.	0	0
3			9.534E+06	8.802E+05	4.692E+05	0.	0.	1.107E+07	0.	4.144E+06	1.000E+03	0	45
4			1.034E+06	2.069E+06	5.845E+05	0.	0.	1.148E+07	0.	8.265E+05	0.	0	128
5			1.020E+05	4.038E+06	6.297E+05	0.	0.	1.152E+07	0.	1.032E+05	1.271E+04	0	187
6			0.	9.414E+06	6.120E+05	0.	0.	1.056E+07	0.	0.	1.967E+05	0	200
7			0.	1.212E+07	6.793E+05	0.	0.	1.152E+07	0.	0.	4.464E+05	0	220
8			0.	1.126E+07	6.760E+05	0.	0.	1.152E+07	0.	0.	3.487E+05	0	220
9			0.	5.642E+06	5.943E+05	0.	0.	1.056E+07	0.	0.	1.717E+04	0	189
10			1.808E+06	2.554E+06	5.529E+05	0.	0.	1.107E+07	0.	8.241E+05	1.357E+04	0	200
11			9.096E+06	2.007E+05	4.218E+05	0.	0.	1.056E+07	0.	4.103E+06	0.	0	574
12			2.270E+07	0.	3.976E+05	0.	0.	1.056E+07	0.	8.192E+06	0.	0	0
FINAL			9.264E+07	4.821E+07	6.420E+06	0.	0.	1.325E+08	0.	3.775E+07	1.036E+06	0	3566

MAXIMUM HEATING LOAD = 1.367E+05 AT HOUR 8 ON DAY 8 OF MONTH 1 WITH A ZONE AIR TEMP OF 67.51
 MAXIMUM COOLING LOAD = 8.210E+04 AT HOUR 14 ON DAY 23 OF MONTH 8 WITH A ZONE AIR TEMP OF 78.68
 MAXIMUM ZONE AIR TEMP = 1.040E+02 AT HOUR 14 ON DAY 24 OF MONTH 8
 MINIMUM ZONE AIR TEMP = 6.127E+01 AT HOUR 7 ON DAY 8 OF MONTH 1

INFILTRATION HEAT GAIN/LOSS REFERS TO SENSIBLE PORTION ONLY.
 LATENT PORTION IS COMPUTED BY AIR HANDLING SYSTEM SUBPROGRAM.
 LOSS = MASS FLOW * SPECIFIC HEAT * (ZONE TEMP - OUTSIDE TEMP)
 IT IS INCLUDED IN TOTAL SENSIBLE LOAD.

20040 MEDICAL DISPEN

LEFT BUILDING UNIT

3%

LOADS SUMMARY FOR ZONE

#RIGHT PATIENTS IN A F 8

MO	DAY	HR	HEATING LOAD (BTU)	COOLING LOAD (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	RADIANT LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILT HEAT LOSS (BTU)	INFILT HEAT GAIN (BTU)	MAT/ H EX	IMB/ C IN	C EX
1			2.842E+07	0.	4.213E+05	0.	0.	8.492E+06	0.	1.081E+07	0.	0	741	0
2			2.365E+07	0.	3.950E+05	0.	0.	7.752E+06	0.	9.922E+06	0.	0	691	0
3			1.075E+07	4.168E+05	4.498E+05	0.	0.	8.160E+06	0.	4.666E+06	1.364E+03	0	543	32
4			1.414E+06	7.685E+05	5.435E+05	0.	0.	8.454E+06	0.	1.211E+06	0.	0	171	81
5			1.757E+05	1.919E+06	5.992E+05	0.	0.	8.492E+06	0.	2.391E+05	1.416E+04	0	31	145
6			0.	6.977E+06	6.056E+05	0.	0.	7.790E+06	0.	0.	2.078E+05	0	0	199
7			0.	9.409E+06	6.726E+05	0.	0.	8.492E+06	0.	0.	4.653E+05	0	0	220
8			0.	8.544E+06	6.685E+05	0.	0.	8.492E+06	0.	0.	3.638E+05	0	0	216
9			0.	3.651E+06	5.815E+05	0.	0.	7.790E+06	0.	0.	1.939E+04	0	0	170
10			2.264E+06	1.355E+06	5.234E+05	0.	0.	8.160E+06	0.	1.230E+06	1.537E+04	0	230	90
11			9.351E+06	6.063E+04	4.052E+05	0.	0.	7.790E+06	0.	4.582E+06	0.	0	614	8
12			2.392E+07	0.	3.851E+05	0.	0.	7.790E+06	0.	8.287E+06	0.	0	719	0
FINAL			9.995E+07	3.312E+07	6.241E+06	0.	0.	9.765E+07	0.	3.994E+07	1.087E+06	0	3740	1161

MAXIMUM HEATING LOAD = 1.408E+05 AT HOUR 8 ON DAY 8 OF MONTH 1 WITH A ZONE AIR TEMP OF 67.47
 MAXIMUM COOLING LOAD = 6.939E+04 AT HOUR 14 ON DAY 23 OF MONTH 8 WITH A ZONE AIR TEMP OF 78.42
 MAXIMUM ZONE AIR TEMP = 1.015E+02 AT HOUR 14 ON DAY 24 OF MONTH 8
 MINIMUM ZONE AIR TEMP = 6.129E+01 AT HOUR 7 ON DAY 8 OF MONTH 1

INFILTRATION HEAT GAIN/LOSS REFERS TO SENSIBLE PORTION ONLY.
 LATENT PORTION IS COMPUTED BY AIR HANDLING SYSTEM SUBPROGRAM.
 LOSS = MASS FLOW * SPECIFIC HEAT * (ZONE TEMP - OUTSIDE TEMP)
 IT IS INCLUDED IN TOTAL SENSIBLE LOAD.

LOADS SUMMARY FOR ZONE 4X MONTH BASEMENT				20040 MEDICAL DISPENS									
NIGHT PATIENTS ON A F B													
40 DY HR	HEATING LOAD (BTU)	COOLING LOAD (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	BASEBOARD LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILT HEAT LOSS (BTU)	INFILT HEAT GAIN (BTU)	NAT/ H EX H OM C IN C EX			
1	2.10E+07	0.	1.37E+05	0.	0.	3.37E+06	0.	5.27E+06	0.	0	744	0	0
2	1.92E+07	0.	1.25E+05	0.	0.	3.07E+06	0.	4.35E+06	0.	0	696	0	0
3	1.34E+07	0.	1.33E+05	0.	0.	3.24E+06	0.	2.36E+06	0.	0	738	0	0
4	1.02E+07	0.	1.41E+05	0.	0.	3.35E+06	0.	1.14E+06	0.	0	702	0	0
5	9.14E+06	0.	1.41E+05	0.	0.	3.37E+06	0.	5.61E+05	0.	0	714	0	0
6	2.16E+05	0.	1.48E+05	0.	0.	3.09E+06	0.	1.02E+04	0.	0	53	0	0
7	0.	0.	1.76E+05	0.	0.	3.37E+06	0.	0.	0.	0	0	0	0
8	1.80E+03	0.	1.71E+05	0.	0.	3.37E+06	0.	2.18E+04	0.	0	4	0	0
9	9.62E+05	0.	1.32E+05	0.	0.	3.09E+06	0.	2.95E+05	0.	0	161	0	0
10	2.81E+06	0.	1.37E+05	0.	0.	3.24E+06	0.	9.35E+05	0.	0	271	0	0
11	5.01E+06	0.	1.29E+05	0.	0.	3.09E+06	0.	2.22E+06	0.	0	427	0	0
12	1.87E+07	0.	1.25E+05	0.	0.	3.09E+06	0.	4.03E+06	0.	0	720	0	0
FINAL	1.01E+08	0.	1.70E+06	0.	0.	3.87E+07	0.	2.12E+07	0.	0	5230	0	0

MAXIMUM HEATING LOAD = 9.79E+04 AT HOUR 8 ON DAY 8 OF MONTH
 MAXIMUM COOLING LOAD = 0. AT HOUR 0 ON DAY 0 OF MONTH
 MAXIMUM ZONE AIR TEMP = 7.61E+01 AT HOUR 16 ON DAY 18 OF MONTH
 MINIMUM ZONE AIR TEMP = 6.13E+01 AT HOUR 7 ON DAY 8 OF MONTH

INFILTRATION HEAT GAIN/LOSS REFERS TO SENSIBLE PORTION ONLY.
 LATENT PORTION IS COMPUTED BY AIR HANDLING SYSTEM SUBPROGRAM.
 LOSS = MASS FLOW * SPECIFIC HEAT * (ZONE TEMP - OUTSIDE TEMP)
 IT IS INCLUDED IN TOTAL SENSIBLE LOAD.

LOADS SUMMARY FOR ZONE			5X SOUTH BASEMENT			20040 MEDICAL DISPEN								
WRIGHT PATTERSON AFB														
MO	DAY	HR	HEATING LOAD (BTU)	COOLING LOAD (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	BASEBOARD LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILT HEAT LOSS (BTU)	INFILT HEAT GAIN (BTU)	MAT/ EX H	COB/ OM C	OMB/ C EX
1			2.290E+07	0.	1.368E+05	0.	0.	2.594E+06	0.	5.262E+06	0.	0	744	0
2			2.031E+07	0.	1.248E+05	0.	0.	2.348E+06	0.	4.343E+06	0.	0	696	0
3			1.405E+07	0.	1.333E+05	0.	0.	2.493E+06	0.	2.377E+06	0.	0	737	0
4			1.025E+07	0.	1.410E+05	0.	0.	2.562E+06	0.	1.145E+06	0.	0	702	0
5			8.936E+06	0.	1.417E+05	0.	0.	2.594E+06	0.	5.601E+05	0.	0	713	0
6			2.121E+05	0.	1.483E+05	0.	0.	2.380E+06	0.	1.017E+04	0.	0	38	0
7			0.	0.	1.779E+05	0.	0.	2.594E+06	0.	0.	0.	0	0	0
8			3.867E+03	0.	1.730E+05	0.	0.	2.594E+06	0.	3.032E+04	0.	0	6	0
9			1.003E+06	0.	1.324E+05	0.	0.	2.380E+06	0.	2.951E+05	0.	0	154	0
10			3.215E+06	0.	1.368E+05	0.	0.	2.493E+06	0.	9.398E+05	0.	0	295	0
11			6.039E+06	0.	1.286E+05	0.	0.	2.380E+06	0.	2.263E+06	0.	0	511	0
12			2.010E+07	0.	1.250E+05	0.	0.	2.380E+06	0.	4.027E+06	0.	0	720	0
FINAL			1.070E+08	0.	1.700E+06	0.	0.	2.983E+07	0.	2.125E+07	0.	0	5316	0

MAXIMUM HEATING LOAD = 9.259E+04 AT HOUR 8 ON DAY 8 OF MONTH 1 WITH A ZONE AIR TEMP OF 67.15
 MAXIMUM COOLING LOAD = 0. AT HOUR 0 ON DAY 0 OF MONTH 0 WITH A ZONE AIR TEMP OF 0.00
 MAXIMUM ZONE AIR TEMP = 7.695E+01 AT HOUR 16 ON DAY 18 OF MONTH 7
 MINIMUM ZONE AIR TEMP = 6.131E+01 AT HOUR 7 ON DAY 8 OF MONTH 1

INFILTRATION HEAT GAIN/LOSS REFERS TO SENSIBLE PORTION ONLY.
 LATENT PORTION IS COMPUTED BY AIR HANDLING SYSTEM SURPHICHAM.
 LOSS = MASS FLOW * SPECIFIC HEAT * (ZONE TEMP - OUTSIDE TEMP)
 IT IS INCLUDED IN TOTAL SENSIBLE LOAD.

 ** AIR HANDLING SYSTEM ENERGY USE SUMMARY **
 **

PROJECT: ENERGY ANALYSIS OF BUILDING 20040

SYSTEM NUMBER = 1 SYSTEM LOCATION = 13040 SIMULATION PERIOD = 1/1/1969 - 12/30/1968
 SYSTEM NAME = MULTIZONE FAN SYSTEM 1 SYSTEM TYPE = MULTIZONE

ELECTRICITY

MONTH	BUILDING LIGHTS CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	FANS CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	HEATING CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	TOTAL USE CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)
JAN	4.312E+07	1.720E+05	1.241E+07	1.667E+04	0.	0.	5.553E+07	1.887E+05
FEB	3.935E+07	1.720E+05	1.161E+07	1.667E+04	0.	0.	5.095E+07	1.887E+05
MAR	4.141E+07	1.720E+05	1.139E+07	1.667E+04	0.	0.	5.280E+07	1.887E+05
APR	4.294E+07	1.720E+05	9.604E+06	1.667E+04	0.	0.	5.255E+07	1.887E+05
MAY	4.312E+07	1.720E+05	9.288E+06	1.667E+04	0.	0.	5.241E+07	1.887E+05
JUN	3.953E+07	1.720E+05	8.004E+06	1.667E+04	0.	0.	4.753E+07	1.887E+05
JUL	4.312E+07	1.720E+05	9.204E+06	1.667E+04	0.	0.	5.233E+07	1.887E+05
AUG	4.312E+07	1.720E+05	8.804E+06	1.667E+04	0.	0.	5.192E+07	1.887E+05
SEP	3.953E+07	1.720E+05	8.404E+06	1.667E+04	0.	0.	4.793E+07	1.887E+05
OCT	4.141E+07	1.720E+05	1.035E+07	1.667E+04	0.	0.	5.177E+07	1.887E+05
NOV	3.953E+07	1.720E+05	1.146E+07	1.667E+04	0.	0.	5.098E+07	1.887E+05
DEC	3.953E+07	1.720E+05	1.201E+07	1.667E+04	0.	0.	5.153E+07	1.887E+05
ANNUAL	4.957E+04	1.720E+05	1.225E+04	1.667E+04	0.	0.	6.182E+08	1.887E+05

CYRIL -- H.L.A.S.T. ---				VERSION 2.0 LVL 100.65		6 AUG 81		19.06.11.		PAGE 37	
MONTH	G A S		S T E A M		H O T W A T E R		C H I L L E D W A T E R				
	TOTAL USE CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	TOTAL USE CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	TOTAL USE CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	TOTAL USE CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)			
JAN	0.	0.	1.531E+08	7.160E+05	0.	0.	0.	0.	0.	0.	
FEB	0.	0.	1.201E+08	5.919E+05	0.	0.	0.	0.	0.	0.	
MAR	0.	0.	5.743E+07	4.427E+05	0.	0.	0.	0.	0.	0.	
APR	0.	0.	1.167E+07	1.437E+05	0.	0.	0.	0.	0.	0.	
MAY	0.	0.	5.410E+06	9.987E+04	0.	0.	0.	0.	0.	0.	
JUN	0.	0.	0.	0.	0.	0.	5.709E+07	5.190E+05	0.	0.	
JUL	0.	0.	0.	0.	0.	0.	8.269E+07	5.610E+05	0.	0.	
AUG	0.	0.	0.	0.	0.	0.	7.634E+07	5.650E+05	0.	0.	
SEP	0.	0.	0.	0.	0.	0.	3.221E+07	3.440E+05	0.	0.	
OCT	0.	0.	1.520E+07	2.013E+05	0.	0.	0.	0.	0.	0.	
NOV	0.	0.	5.081E+07	3.183E+05	0.	0.	0.	0.	0.	0.	
DEC	0.	0.	1.260E+08	4.906E+05	0.	0.	0.	0.	0.	0.	
ANN	0.	0.	5.487E+08	7.160E+05	0.	0.	2.483E+08	5.650E+05	0.	0.	

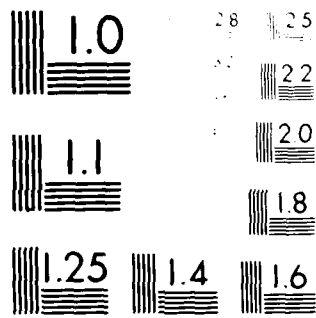
AD-A109 876 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL--ETC F/G 13/1
AN ECONOMIC ANALYSIS OF AIR-CONDITIONING SYSTEMS WITH OFF-PEAK --ETC(U)
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

 ** AIR HANDLING SYSTEM COMPONENT LOAD SUMMARY **
 **

PROJECT: ENERGY ANALYSIS OF BUILDING 20040

SYSTEM NUMBER = 1 SIMULATION PERIOD = 1/1/1968 - 12/30/1968

SYSTEM LOCATION = 13840

SYSTEM TYPE = MULTIZONE

SYSTEM NAME = MULTIZONE FAN SYSTEM 1

HRS CAP EXCD
(HOURS)

PK CAP EXCD
(BTU/HR)

HRS CONSUMPTN
(HOURS)

PEAK DEMAND
(BTU/HR)

CONSUMPTION
(BTU)

MONTH

HEATING COIL LOADS

178

MONTH	CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	HRS CONSUMPTN (HOURS)	PK CAP EXCD (BTU/HR)	HRS CAP EXCD (HOURS)
JAN	1.531E+09	7.160E+05	744.	0.	0.
FEB	1.291E+09	5.918E+05	695.	0.	0.
MAR	5.743E+07	4.427E+05	621.	0.	0.
APR	1.167E+07	1.437E+05	480.	0.	0.
MAY	5.416E+06	9.947E+04	399.	0.	0.
JUN	0.	0.	0.	0.	0.
JUL	0.	0.	0.	0.	0.
AUG	0.	0.	0.	0.	0.
SEP	1.520E+07	2.013E+05	473.	0.	0.
OCT	5.081E+07	3.183E+05	666.	0.	0.
NOV	1.260E+09	4.806E+05	720.	0.	0.
DEC					
ANN	5.487E+09	7.160E+05	4787.	0.	0.

Cooling COIL LOADS

MONTH	CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	HRS CONSUMPTN (HOURS)	PK CAP EXCD (BTU/HR)	HRS CAP EXCD (HOURS)
JAN	0.	0.	0.	0.	0.
FEB	0.	0.	0.	0.	0.
MAR	0.	0.	0.	0.	0.
APR	0.	0.	0.	0.	0.
MAY	0.	0.	0.	0.	0.
JUN	5.709E+07	5.196E+05	481.	6.945E+04	14.
JUL	9.269E+07	5.616E+05	552.	1.114E+05	38.
AUG	7.634E+07	5.656E+05	524.	1.155E+05	54.
SEP	3.221E+07	3.446E+05	502.	0.	0.
OCT	0.	0.	0.	0.	0.
NOV	0.	0.	0.	0.	0.
DEC	0.	0.	0.	0.	0.
ANN	2.483E+09	5.616E+05	2058.	1.155E+05	106.

 ** AIR HANDLING SYSTEM ENERGY USE SUMMARY **
 **

PROJECT ENERGY ANALYSIS OF BUILDING 20040

SYSTEM NUMBER = 2 SYSTEM LOCATION = 10040 SIMULATION PERIOD = 1/1/1968 - 12/30/1968
 SYSTEM NAME = MULTIZONE FAN SYSTEM SYSTEM TYPE = MULTIZONE

ELECTRICITY

MONTH	BUILDING LIGHTS			FANS			HEATING			TOTAL USE	
	CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	CONSUMPTION (BTU)	CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	CONSUMPTION (BTU)	CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	CONSUMPTION (BTU)
JAN	5.966E+06	2.300E+04	2.841E+06	3.819E+03	0.	0.	0.	0.	8.807E+06	2.682E+04	8.807E+06
FEB	5.446E+06	2.300E+04	2.699E+06	3.819E+03	0.	0.	0.	0.	8.104E+06	2.682E+04	8.104E+06
MAR	5.734E+06	2.300E+04	2.841E+06	3.819E+03	0.	0.	0.	0.	8.575E+06	2.682E+04	8.575E+06
APR	5.930E+06	2.300E+04	2.750E+06	3.819E+03	0.	0.	0.	0.	8.686E+06	2.682E+04	8.686E+06
MAY	5.966E+06	2.300E+04	2.841E+06	3.819E+03	0.	0.	0.	0.	8.807E+06	2.682E+04	8.807E+06
JUN	5.474E+06	2.300E+04	1.949E+06	3.819E+03	0.	0.	0.	0.	7.422E+06	2.682E+04	7.422E+06
JUL	5.966E+06	2.300E+04	2.109E+06	3.819E+03	0.	0.	0.	0.	8.074E+06	2.682E+04	8.074E+06
AUG	5.966E+06	2.300E+04	2.010E+06	3.819E+03	0.	0.	0.	0.	7.983E+06	2.682E+04	7.983E+06
SEP	5.474E+06	2.300E+04	1.925E+06	3.819E+03	0.	0.	0.	0.	7.399E+06	2.682E+04	7.399E+06
OCT	5.734E+06	2.300E+04	2.230E+06	3.819E+03	0.	0.	0.	0.	7.972E+06	2.682E+04	7.972E+06
NOV	5.8474E+06	2.300E+04	2.501E+06	3.819E+03	0.	0.	0.	0.	7.975E+06	2.682E+04	7.975E+06
DEC	5.474E+06	2.300E+04	2.750E+06	3.819E+03	0.	0.	0.	0.	8.224E+06	2.682E+04	8.224E+06
ANNUAL	6.801E+07	2.300E+04	2.942E+07	3.819E+03	0.	0.	0.	0.	9.801E+07	2.682E+04	9.801E+07

MONTH	G A S		S T E A M		H O T W A T E R		C H I L L E D W A T E R	
	TOTAL USE CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	TOTAL USE CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	TOTAL USE CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	TOTAL USE CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)
JAN	0.	0.	5.160E+07	2.030E+05	0.	0.	0.	0.
FEB	0.	0.	4.603E+07	1.789E+05	0.	0.	0.	0.
MAR	0.	0.	2.995E+07	1.479E+05	0.	0.	0.	0.
APR	0.	0.	2.042E+07	9.662E+04	0.	0.	0.	0.
MAY	0.	0.	1.662E+07	9.950E+04	0.	0.	0.	0.
JUN	0.	0.	0.	0.	0.	0.	4.125E+06	2.573E+04
JUL	0.	0.	0.	0.	0.	0.	6.362E+06	2.596E+04
AUG	0.	0.	0.	0.	0.	0.	5.939E+06	2.641E+04
SEP	0.	0.	0.	0.	0.	0.	2.415E+06	2.137E+04
OCT	0.	0.	6.950E+06	9.204E+04	0.	0.	0.	0.
NOV	0.	0.	1.340E+07	1.025E+05	0.	0.	0.	0.
DEC	0.	0.	4.448E+07	1.606E+05	0.	0.	0.	0.
ANN	0.	0.	2.297E+08	2.030E+05	0.	0.	1.894E+07	2.661E+04

 **
 ** AIR HANDLING SYSTEM COMPONENT LOAD SUMMARY **
 **

PROJECT: ENERGY ANALYSIS OF BUILDING 20040

SYSTEM NUMBER = 2 SIMULATION PERIOD = 1/1/1968 - 12/30/1968

SYSTEM LOCATION = 13840

SYSTEM TYPE = MULTIZONE

SYSTEM NAME = MULTIZONE FAN SYSTEM

181

HEATING COIL LOADS

MONTH	CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	HRS CONSUMPTN (HOURS)	PK CAP EXCD (BTU/HR)	HRS CAP EXCD (HOURS)
JAN	5.160E+07	2.030E+05	744.	0.	0.
FEB	4.603E+07	1.779E+05	696.	0.	0.
MAR	2.995E+07	1.479E+05	733.	0.	0.
APR	2.042E+07	9.662E+04	699.	0.	0.
MAY	1.667E+07	9.850E+04	698.	0.	0.
JUN	0.	0.	0.	0.	0.
JUL	0.	0.	0.	0.	0.
AUG	0.	0.	0.	0.	0.
SEP	0.	0.	0.	0.	0.
OCT	6.950E+06	9.204E+04	407.	0.	0.
NOV	1.360E+07	1.025E+05	608.	0.	0.
DEC	4.448E+07	1.606E+05	720.	0.	0.
ANN	2.297E+08	2.030E+05	5305.	0.	0.

Cooling COIL LOADS

MONTH	CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	HRS CONSUMPTN (HOURS)	PK CAP EXCD (BTU/HR)	HRS CAP EXCD (HOURS)
JAN	0.	0.	0.	0.	0.
FEB	0.	0.	0.	0.	0.
MAR	0.	0.	0.	0.	0.
APR	0.	0.	0.	0.	0.
MAY	0.	0.	0.	0.	0.
JUN	4.125E+06	2.573E+04	464.	0.	0.
JUL	6.367E+06	2.598E+04	541.	0.	0.
AUG	5.939E+06	2.661E+04	484.	0.	0.
SEP	2.415E+06	2.117E+04	334.	0.	0.
OCT	0.	0.	0.	0.	0.
NOV	0.	0.	0.	0.	0.
DEC	0.	0.	0.	0.	0.
ANN	1.884E+07	2.661E+04	1827.	0.	0.

 ** AIR HANDLING SYSTEM LOADS NOT MET SUMMARY **

PROJECT: ENERGY ANALYSIS OF BUILDING 20040

SYSTEM NUMBER = 2

SYSTEM LOCATION = 13040

SIMULATION PERIOD = 1/1/1968 - 12/30/1968

SYSTEM TYPE = MULTIZONE

SYSTEM NAME = MULTIZONE FAN SYSTEM

COOLING

HEATING

MONTH	LOAD NOT MET (BTU)	PEAK NOT MET (BTU/HR)	HOURS NOT MET (HOURS)	LOAD NOT MET (BTU)	PEAK NOT MET (BTU/HR)	HOURS NOT MET (HOURS)
ZONE 4						
JAN	0.	0.	0.	0.	0.	0.
FEB	0.	0.	0.	0.	0.	0.
MAR	6.799E+03	2.648E+03	7.	2.292E+04	4.014E+03	12.
APR	6.611E+03	1.998E+03	7.	3.858E+04	4.070E+03	21.
MAY	1.319E+04	2.787E+03	10.	1.095E+05	5.325E+03	46.
JUN	1.870E+05	2.173E+04	51.	0.	0.	0.
JUL	5.742E+03	1.295E+03	11.	0.	0.	0.
AUG	3.053E+04	2.494E+03	41.	0.	0.	0.
SEP	8.793E+05	2.445E+04	165.	0.	0.	0.
OCT	0.	0.	0.	4.045E+05	5.661E+03	186.
NOV	0.	0.	0.	4.099E+04	2.927E+03	49.
DEC	0.	0.	0.	0.	0.	0.
ANN	1.109E+06	2.445E+04	292.	6.160E+05	5.661E+03	313.
ZONE 5						
JAN	0.	0.	0.	0.	0.	0.
FEB	0.	0.	0.	0.	0.	0.
MAR	3.907E+03	2.263E+03	5.	3.173E+04	4.031E+03	15.
APR	2.159E+03	1.469E+03	2.	5.107E+04	4.063E+03	30.
MAY	5.831E+03	1.793E+03	6.	1.416E+05	5.029E+03	68.
JUN	1.703E+05	2.261E+04	63.	0.	0.	0.
JUL	1.362E+04	1.299E+03	30.	0.	0.	0.
AUG	6.676E+04	3.171E+03	69.	0.	0.	0.
SEP	9.399E+05	2.522E+04	186.	3.497E+05	4.749E+03	191.
OCT	0.	0.	0.	6.695E+04	3.503E+03	84.
NOV	0.	0.	0.	0.	0.	0.
DEC	0.	0.	0.	0.	0.	0.
ANN	1.201E+06	2.522E+04	361.	6.410E+05	5.029E+03	388.

 ** TIME OF DAY ELECTRICAL USAGE REPORT **

PROJECT: ENERGY ANALYSIS OF BUILDING 20040

PLANT NUMBER = 1 PLANT LOCATION = 13940 SIMULATION PERIOD = 1/1/1968 - 12/30/1968

PLANT NAME = CENTRAL PLANT SYSTEM 1

MONTH	RATE 1 (KWH)	DEMAND 1 (KW)	RATE 2 (KWH)	DEMAND 2 (KW)	RATE 3 (KWH)	DEMAND 3 (KW)	RATE 4 (KWH)	DEMAND 4 (KW)	RATE 5 (KWH)	DEMAND 5 (KW)
1	0.	0.	0.	0.	1.6802E+04	6.4928E+01	3.3901E+03	1.8595E+01	0.	0.
2	0.	0.	0.	0.	1.5393E+04	6.4928E+01	3.1666E+03	1.8595E+01	0.	0.
3	0.	0.	0.	0.	1.6030E+04	6.4928E+01	3.2841E+03	1.8595E+01	0.	0.
4	0.	0.	0.	0.	1.6088E+04	6.4928E+01	3.1451E+03	6.1706E+01	0.	0.
5	0.	0.	0.	0.	1.5094E+04	6.4928E+01	4.1487E+03	6.1706E+01	0.	0.
6	1.2672E+04	1.1154E+02	1.3913E+04	1.0753E+02	0.	0.	0.	0.	0.	0.
7	1.4411E+04	1.1430E+02	1.5764E+04	1.1010E+02	0.	0.	0.	0.	0.	0.
8	1.4149E+04	1.1376E+02	1.5260E+04	1.1209E+02	0.	0.	0.	0.	0.	0.
9	1.1974E+04	9.9547E+01	1.3135E+04	9.5772E+01	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	1.4508E+04	6.4928E+01	3.8927E+03	6.1706E+01	0.	0.
11	0.	0.	0.	0.	1.5364E+04	6.4928E+01	3.1285E+03	1.8595E+01	0.	0.
12	0.	0.	0.	0.	1.5538E+04	6.4928E+01	3.2701E+03	1.8595E+01	0.	0.
Avg	5.3206E+04	1.1430E+02	5.4005E+04	1.1200E+02	1.2409E+05	6.4928E+01	2.7426E+04	6.1706E+01	0.	0.

EQUIPMENT USE STATISTICS

PROJECT: ENERGY ANALYSIS OF BUILDING 20040

SIMULATION PERIOD - 1/1/1969 - 12/30/1968

PLANT LOCATION - 13040

PLANT NUMBER = 1 PI

EQUIPMENT		AVG OPER RATIO	MAX LOAD (KBTU/H)	MM DY	HR	SIZE (KBTU/H)	OPER HOURS	SIZE (KBTU/H)	OPER HOURS
STEAM BOILER		.122	959.	1	6	1033.	7123		
REFRIGERATING CHILLER		.268	576.	7	18	480.	2079		
UTILITY, F W E R O Y		1 YR UNADJ COST (K\$)	1-YEAR USAGE (KBTU)	PEAK USAGE (KBTU/H)		COST ESCALATION FACTOR			
ELEC		15.3	.900	390.3		0.090			
BOILER		12.0	1.592	1327.3		0.000			
UTILITY, ENERGY TOTAL		27.3							

 ** TIME OF DAY ELECTRICAL USAGE REPORT **

PROJECT: ENERGY ANALYSIS OF BUILDING 20040

PLANT NUMBER = 2 PLANT LOCATION = 13040 SIMULATION PERIOD = 1/ 1/1968 - 12/30/1968

PLANT NAME = COLD STORAGE CHILLER 12 HOUR OPERATION

185

WYTH	RATE 1 (KWH)	DEMAND 1 (KW)	RATE 2 (KWH)	DEMAND 2 (KW)	RATE 3 (KWH)	DEMAND 3 (KW)	RATE 4 (KWH)	DEMAND 4 (KW)	RATE 5 (KWH)	DEMAND 5 (KW)
1	0.	0.	0.	0.	1.6802E+04	6.4928E+01	3.3901E+03	1.8595E+01	0.	0.
2	0.	0.	0.	0.	1.5393E+04	6.4928E+01	3.1666E+03	1.8595E+01	0.	0.
3	0.	0.	0.	0.	1.6030E+04	6.4928E+01	3.2841E+03	1.8595E+01	0.	0.
4	0.	0.	0.	0.	1.6088E+04	6.4928E+01	3.1451E+03	6.1706E+01	0.	0.
5	0.	0.	0.	0.	1.5096E+04	6.4928E+01	4.1487E+03	6.1706E+01	0.	0.
6	9.7475E+03	6.3113E+01	1.4516E+04	1.0709E+02	0.	0.	0.	0.	0.	0.
7	1.0576E+04	6.3113E+01	1.6482E+04	1.0457E+02	0.	0.	0.	0.	0.	0.
8	1.0526E+04	6.3113E+01	1.6204E+04	1.0438E+02	0.	0.	0.	0.	0.	0.
9	9.6439E+03	6.3113E+01	1.2412E+04	8.5510E+01	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	1.4588E+04	6.4928E+01	3.8927E+03	6.1706E+01	0.	0.
11	0.	0.	0.	0.	1.5364E+04	6.4928E+01	3.1285E+03	1.8595E+01	0.	0.
12	0.	0.	0.	0.	1.5539E+04	6.4928E+01	3.2701E+03	1.8595E+01	0.	0.
AIR	4.0493E+04	6.3113E+01	5.0813E+04	1.0457E+02	1.2400E+05	6.4928E+01	2.7426E+04	6.1706E+01	0.	0.

 **
 ** CHILLED AND HOT WATER LOADS NOT MET REPORT **
 **

PROJECT: ENERGY ANALYSIS OF BUILDING 20040

SIMULATION PERIOD = 1/ 1/1968 - 12/30/1968

PLANT LOCATION = 13840

2

PLANT NUMBER =

PLANT NAME = CHILL STORAGE CHILLER 12 HOUR OPERATION

186

MONTH	HOT WATER (BTU)	CHILLED WATER (BTU)
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	0.
8	0.	0.
9	0.	0.
10	0.	0.
11	0.	0.
12	0.	0.
ANN	0.	0.

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EQUIPMENT USE STATISTICS

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PROJECT: ENERGY ANALYSIS OF BUILDING 20040

PLANT NUMBER = 2 PLANT LOCATION = 13840 SIMULATION PERIOD = 1/ 1/1968 - 12/30/1968
PLANT NAME = COLD STORAGE CHILLER 12 HOUR OPERATION

EQUIPMENT											
AVG (OPER RATIO)		MAX LOAD (KBTU)		MIN DY HR		SIZE (KBTU)		OPER HOURS		SIZE (KBTU)	
.122		959.		1 0 0		1033.		7123			
.522		480.		9 20 20		480.		1090			
0.000		0.		0 0 0		6000.		0			
UTILITY, ENERGY											
IYR UNADJ COST (K\$)		I-YEAR USAGE (KBTU)		PEAK USAGE (KBTU)		COST ESCALATION FACTOR					
14.7		.863		357.0		0.000					
12.0		1.592		1127.3		0.000					
UTILITY, ENERGY TOTAL											
								26.7			

 **
 ** TIME OF DAY ELECTRICAL USAGE REPORT **
 **

PROJECT: ENERGY ANALYSIS OF BUILDING 20040

PLANT NUMBER = 3 PLANT LOCATION = 13840 SIMULATION PERIOD = 1/1/1968 - 12/30/1968
 PLANT NAME = CHILD STORAGE CHILLER 24 HOUR OPERATION

MONTH	RATE 1 (KWH)	DEMAND 1 (KW)	RATE 2 (KWH)	DEMAND 2 (KW)	RATE 3 (KWH)	DEMAND 3 (KW)	RATE 4 (KWH)	DEMAND 4 (KW)	RATE 5 (KWH)	DEMAND 5 (KW)
1	0.	0.	0.	0.	1.6802E+04	6.4920E+01	3.3901E+03	1.8595E+01	0.	0.
2	0.	0.	0.	0.	1.5303E+04	6.4920E+01	3.1666E+03	1.8595E+01	0.	0.
3	0.	0.	0.	0.	1.6030E+04	6.4920E+01	3.2841E+03	1.8595E+01	0.	0.
4	0.	0.	0.	0.	1.6000E+04	6.4920E+01	3.1451E+03	6.1706E+01	0.	0.
5	0.	0.	0.	0.	1.5094E+04	6.4920E+01	4.1487E+03	6.1706E+01	0.	0.
6	1.1885E+04	8.9227E+01	1.2580E+04	8.9219E+01	0.	0.	0.	0.	0.	0.
7	1.3210E+04	9.9536E+01	1.3851E+04	9.7481E+01	0.	0.	0.	0.	0.	0.
8	1.2811E+04	8.7697E+01	1.3567E+04	8.7915E+01	0.	0.	0.	0.	0.	0.
9	1.0099E+04	8.8200E+01	1.1247E+04	8.7950E+01	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	1.4591E+04	6.4920E+01	3.8927E+03	6.1706E+01	0.	0.
11	0.	0.	0.	0.	1.5164E+04	6.4920E+01	3.1285E+03	1.8595E+01	0.	0.
12	0.	0.	0.	0.	1.5531E+04	6.4920E+01	3.2701E+03	1.8595E+01	0.	0.
ANU	4.8901E+04	8.9536E+01	5.1294E+04	8.9219E+01	1.2400E+05	6.4920E+01	2.7426E+04	6.1706E+01	0.	0.

 ** CHILLED AND HOT WATER LOADS NOT MET REPORT **
 **

PROJECT: ENERGY ANALYSIS OF BUILDING 20040

SIMULATION PERIOD = 1/ 1/1968 - 12/30/1968

PLANT NUMBER = 3 PLANT LOCATION = 13040

PLANT NAME = CHLD STORAGE CHILLER 24 HOUR OPERATION

MONTH	HOT WATER (BTU)	CHILLED WATER (BTU)
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	.3543E+06
7	0.	.1321E+07
8	0.	.1778E+07
9	0.	0.
10	0.	0.
11	0.	0.
12	0.	0.
ANNU	0.	3.4537E+06

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 EQUIPMENT USE STATISTICS

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PROJECT: ENERGY ANALYSIS OF BUILDING 20040

PLANT NUMBER = 3 PLANT LOCATION = 13040 SIMULATION PERIOD = 1/ 1/1968 - 12/30/1968

PLANT NAME = COLD STORAGE CHILLER 24 HOUR OPERATION

EQUIPMENT	AVG OPER RATIO	MAX LOAD (KBTU)	MON	DY	HR	SIZE (KBTU)	OPER HOURS	SIZE (KBTU)	OPER HOURS
STEAM BOILER	.122	959.	1	0	0	1033.	7123		
RECIPROCATING CHILLER	.438	240.	9	24	17	240.	2120		
COLD WATER TANK	0.000	0.	0	0	0	4000.	0		

UTILITY, ENERGY

	1YR UNADJ COST (K\$)	1-YEAR USAGE (KBTU)	PEAK USAGE (KBTU)	COST ESCALATION FACTOR
ELECT	14.6	.861	305.7	0.000
BOILER	12.0	1.592	1127.3	0.000

UTILITY, ENERGY TOTAL 26.6

APPENDIX D
BLAST OUTPUT REPORTS FOR
BUILDING 20050

LOADS SUMMARY FOR ZONE 1X BASEMENT LEFT WING 20050 ACFT HSCN ENG

ORIGINS PATTERN A F D

NO	DAY	HEATING LOAD (BTU)	CYLINDRICAL LOAD (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	BASEBOARD LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILT HEAT LOSS (BTU)	INFILT HEAT GAIN (BTU)	MAL/ H EX H OM C IN C EX
1		2.539E+07	0.	3.170E+05	0.	0.	3.581E+07	0.	2.451E+07	0.	41 612 0 0
2		2.021E+07	0.	2.981E+05	0.	0.	3.314E+07	0.	2.045E+07	0.	15 590 0 0
3		6.349E+06	7.284E+05	3.673E+05	0.	0.	3.522E+07	0.	9.580E+06	2.505E+03	1 235 35 0
4		2.908E+05	1.501E+06	4.598E+05	0.	0.	3.507E+07	0.	1.596E+06	0.	0 24 91 0
5		1.234E+04	3.861E+06	5.050E+05	0.	0.	3.581E+07	0.	1.173E+05	3.001E+04	0 2 168 0
6		0.	1.486E+07	4.980E+05	0.	0.	3.390E+07	0.	0.	4.440E+05	0 0 200 0
7		0.	1.963E+07	5.542E+05	0.	0.	3.581E+07	0.	0.	1.009E+06	0 0 215 5
8		0.	1.888E+07	5.509E+05	0.	0.	3.581E+07	0.	0.	7.954E+05	0 0 220 0
9		0.	9.741E+06	4.882E+05	0.	0.	3.390E+07	0.	0.	3.608E+04	0 0 200 0
10		7.161E+04	4.549E+06	4.705E+05	0.	0.	3.522E+07	0.	5.274E+05	2.811E+04	0 9 131 0
11		2.429E+06	5.021E+05	3.537E+05	0.	0.	3.390E+07	0.	7.566E+06	0.	0 107 21 0
12		1.789E+07	0.	3.021E+05	0.	0.	3.390E+07	0.	1.875E+07	0.	5 567 0 0
FINAL		7.263E+07	7.138E+07	5.165E+06	0.	0.	4.175E+08	0.	8.309E+07	2.345E+06	62 2146 1281 5

MAXIMUM HEATING LOAD = 1.370E+05 AT HOUR 8 ON DAY 2 OF MONTH 1 WITH A ZONE AIR TEMP OF 65.14
 MAXIMUM CYLINDRICAL LOAD = 1.160E+05 AT HOUR 15 ON DAY 18 OF MONTH 7 WITH A ZONE AIR TEMP OF 79.79
 MAXIMUM ZONE AIR TEMP = 9.393E+01 AT HOUR 17 ON DAY 24 OF MONTH 8
 MINIMUM ZONE AIR TEMP = 5.567E+01 AT HOUR 9 ON DAY 8 OF MONTH 1

INFILTRATION HEAT GAIN/LOSS REFERS TO SENSIBLE PORTION ONLY.
 LATENT PORTION IS COMPUTED BY AIR HANDLING SYSTEM SUBPROGRAM.
 LOSS = MASS FLOW * SPECIFIC HEAT * (ZONE TEMP - OUTSIDE TEMP)
 IT IS INCLUDED IN TOTAL SENSIBLE LOAD.

20050 ACFT RSCH ENG

BASEMENT CENTER

2%

LOADS SUMMARY FOR ZONE

RIGHT PATTERSON A F R

NO	DAY	HR	HEATING LOAD (BTU)	Cooling LOAD (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	BASEBOARD LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILT HEAT LOSS (BTU)	INFILT HEAT GAIN (BTU)	MAT/ H EX	IMB/ C OM	C EX
1			2.323E+07	0.	4.478E+05	0.	0.	1.769E+07	0.	1.639E+07	0.	0	732	0
2			1.860E+07	0.	4.104E+05	0.	0.	1.628E+07	0.	1.340E+07	0.	0	671	0
3			6.971E+06	4.091E+05	4.840E+05	0.	0.	1.723E+07	0.	6.700E+06	2.427E+03	0	434	29
4			4.691E+05	7.247E+05	5.070E+05	0.	0.	1.745E+07	0.	1.263E+06	0.	0	54	74
5			4.272E+04	2.111E+06	6.409E+05	0.	0.	1.769E+07	0.	1.630E+05	2.313E+04	0	5	142
6			0.	9.470E+06	6.454E+05	0.	0.	1.652E+07	0.	0.	3.290E+05	0	0	200
7			0.	1.255E+07	7.149E+05	0.	0.	1.769E+07	0.	0.	7.300E+05	0	0	220
8			0.	1.142E+07	7.122E+05	0.	0.	1.769E+07	0.	0.	5.741E+05	0	0	220
9			0.	5.541E+06	6.342E+05	0.	0.	1.652E+07	0.	0.	3.131E+04	0	0	191
10			2.020E+05	2.333E+06	5.922E+05	0.	0.	1.723E+07	0.	5.942E+05	2.462E+04	0	31	109
11			3.295E+06	1.827E+05	4.513E+05	0.	0.	1.652E+07	0.	5.623E+06	0.	0	247	17
12			1.779E+07	0.	4.107E+05	0.	0.	1.652E+07	0.	1.249E+07	0.	0	694	0
FINAL			7.075E+07	4.474E+07	5.739E+06	0.	0.	2.051E+09	0.	5.670E+07	1.715E+06	0	2968	1202

MAXIMUM HEATING LOAD = 1.647E+05 AT HOUR 8 ON DAY 8 OF MONTH 1 WITH A ZONE AIR TEMP OF 67.14
 MAXIMUM COOLING LOAD = 9.359E+04 AT HOUR 15 ON DAY 18 OF MONTH 7 WITH A ZONE AIR TEMP OF 78.11
 MAXIMUM ZONE AIR TEMP = 9.117E+01 AT HOUR 17 ON DAY 23 OF MONTH 8
 MINIMUM ZONE AIR TEMP = 6.139E+01 AT HOUR 7 ON DAY 8 OF MONTH 1

INFILTRATION HEAT GAIN/LOSS REFERS TO SENSIBLE PORTION ONLY.
 LATENT PORTION IS COMPUTED BY AIR HANDLING SYSTEM SUBPROGRAM.
 LOSS = MASS FLOW * SPECIFIC HEAT * (ZONE TEMP - OUTSIDE TEMP)
 IT IS INCLUDED IN TOTAL SENSIBLE LOAD.

LOADS SUMMARY FOR ZONE 38 FIRST FLOOR LEFT MO

20050 ACFT RSCH ENG

MO	DAY	HEATING LOAD (BTU)	Cooling Load (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	WATER/COOLING LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILTRATION HEAT LOSS (BTU)	INFILTRATION HEAT GAIN (BTU)	MAT/EXH/IN/CON/CEX
1	1	2.14E+07	0.	6.28E+05	0.	0.	1.50E+07	0.	2.19E+07	0.	0 608 0 0
2	2	1.53E+07	0.	5.80E+05	0.	0.	1.44E+07	0.	1.74E+07	0.	0 521 0 0
3	3	4.50E+06	1.98E+06	7.15E+05	0.	0.	1.52E+07	0.	7.53E+06	1.90E+03	0 197 52 0
4	4	1.39E+04	0.04E+06	9.10E+05	0.	0.	1.57E+07	0.	2.05E+05	0.	0 3 167 0
5	5	0.	1.09E+07	9.59E+05	0.	0.	1.50E+07	0.	0.	2.50E+04	0 0 206 0
6	6	0.	1.78E+07	9.01E+05	0.	0.	1.45E+07	0.	0.	4.20E+05	0 0 200 0
7	7	0.	2.24E+07	9.90E+05	0.	0.	1.50E+07	0.	0.	9.95E+05	0 0 220 0
8	8	0.	2.05E+07	9.94E+05	0.	0.	1.50E+07	0.	0.	7.52E+05	0 0 220 0
9	9	0.	1.23E+07	8.99E+05	0.	0.	1.45E+07	0.	0.	3.51E+04	0 0 200 0
10	10	2.41E+05	6.06E+06	8.58E+05	0.	0.	1.52E+07	0.	6.62E+05	2.77E+04	0 18 140 0
11	11	3.97E+06	5.51E+05	6.17E+05	0.	0.	1.45E+07	0.	7.31E+06	0.	0 216 21 0
12	12	1.09E+07	0.	5.74E+05	0.	0.	1.45E+07	0.	1.68E+07	0.	0 617 0 0
<hr/>											
FINAL		6.26E+07	9.80E+07	9.65E+06	0.	0.	1.82E+09	0.	7.19E+07	2.21E+06	0 2180 1426 0

MAXIMUM HEATING LOAD = 2.19E+07 AT HOUR 8 ON DAY 8 OF MONTH 1 WITH A ZONE AIR TEMP OF 67.65
 MAXIMUM COOLING LOAD = 1.43E+05 AT HOUR 14 ON DAY 10 OF MONTH 6 WITH A ZONE AIR TEMP OF 76.57
 MAXIMUM ZONE AIR TEMP = 1.00E+02 AT HOUR 15 ON DAY 24 OF MONTH 6
 MINIMUM ZONE AIR TEMP = 6.16E+01 AT HOUR 19 ON DAY 4 OF MONTH 1

INFILTRATION HEAT GAIN/LOSS REFERS TO SENSIBLE PORTION ONLY.
 LATENT PORTION IS COMPUTED BY AIR HANDLING SYSTEM SURPHOGHAM.
 LOSS = MASS FLOW * SPECIFIC HEAT * (ZONE TEMP - OUTSIDE TEMP)
 IF IS INCLUDED IN TOTAL SENSIBLE LOAD.

LOADS SUMMARY FOR ZONE 4X FIRST FLOOR RIGHT WING

20050 ACFT RSCH ENG

WRIGHT PATTERSON AFB

MO	DAY	HEATING LOAD (BTU)	Cooling Load (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	BASEROUND LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILT HEAT LOSS (BTU)	INFILT HEAT GAIN (BTU)	MAT/ H EX H OM C OM C EX
1		1.085E+07	0.	6.405E+05	0.	0.	1.556E+07	0.	1.795E+07	0.	0 562 0 0
2		1.145E+07	0.	5.926E+05	0.	0.	1.421E+07	0.	1.445E+07	0.	0 490 0 0
3		2.819E+06	2.503E+06	7.450E+05	0.	0.	1.496E+07	0.	5.860E+06	1.246E+03	0 156 69 0
4		0.	7.547E+06	9.409E+05	0.	0.	1.549E+07	0.	0.	0.	0 0 183 0
5		0.	1.139E+07	9.713E+05	0.	0.	1.540E+07	0.	0.	2.020E+04	0 0 213 0
6		0.	1.709E+07	9.101E+05	0.	0.	1.420E+07	0.	0.	3.441E+05	0 0 200 0
7		0.	2.233E+07	1.009E+06	0.	0.	1.556E+07	0.	0.	7.901E+05	0 0 220 0
8		0.	2.090E+07	1.004E+06	0.	0.	1.556E+07	0.	0.	6.207E+05	0 0 220 0
9		0.	1.120E+07	9.960E+05	0.	0.	1.420E+07	0.	0.	2.712E+04	0 0 200 0
10		1.204E+05	7.205E+06	8.820E+05	0.	0.	1.496E+07	0.	3.184E+05	2.079E+04	0 7 159 0
11		2.516E+06	7.331E+05	6.534E+05	0.	0.	1.420E+07	0.	5.082E+06	0.	0 176 29 0
12		1.340E+07	0.	5.909E+05	0.	0.	1.420E+07	0.	1.395E+07	0.	0 593 0 0
FINAL		4.716E+07	1.033E+08	9.836E+06	0.	0.	1.790E+09	0.	5.761E+07	1.824E+06	0 1986 1493 0

MAXIMUM HEATING LOAD = 1.841E+05 AT HOUR 9 ON DAY 8 OF MONTH
 MAXIMUM COOLING LOAD = 1.411E+05 AT HOUR 14 ON DAY 10 OF MONTH
 MAXIMUM ZONE AIR TEMP = 1.051E+02 AT HOUR 14 ON DAY 24 OF MONTH
 MINIMUM ZONE AIR TEMP = 6.160E+01 AT HOUR 7 ON DAY 8 OF MONTH

INFILTRATION HEAT GAIN/LOSS REFERS TO SENSIBLE PORTION ONLY.
 LATENT PORTION IS COVERED BY AIR HANDLING SYSTEM SUBPROGRAM.
 LOSS = MASS FLOW * SPECIFIC HEAT * (ZONE TEMP - OUTSIDE TEMP)
 IT IS INCLUDED IN TOTAL SENSIBLE LOAD.

WILLIAM L. FRANKLIN A F R

NO	BY	HR	HEATING LOAD (BTU)	Cooling Load (BTU)	Latent Load (BTU)	Return Air Heat Gain (BTU)	Baseboard Load (BTU)	Electric Load (BTU)	Gas Load (BTU)	Infilt. Heat Loss (BTU)	Infilt. Heat Gain (BTU)	Mat/ H Ex	ODR/ H OM	IMD/ C OM	C EX
1	1	1	1.457E+07	0.	4.924E+05	0.	0.	1.210E+07	0.	1.446E+07	0.	7	609	0	0
2	2	2	2.540E+06	1.457E+03	4.579E+05	0.	0.	1.113E+07	0.	1.147E+07	0.	0	490	1	0
3	3	3	3.240E+06	2.129E+06	5.760E+05	0.	0.	1.172E+07	0.	4.549E+06	1.259E+03	0	158	65	0
4	4	4	0.	6.983E+06	7.286E+05	0.	0.	1.214E+07	0.	0.	0.	0	0	190	0
5	5	5	0.	1.052E+07	7.502E+05	0.	0.	1.219E+07	0.	0.	1.753E+04	0	0	216	0
6	6	6	0.	1.642E+07	6.989E+05	0.	0.	1.119E+07	0.	0.	2.042E+05	0	0	200	0
7	7	7	0.	1.942E+07	7.730E+05	0.	0.	1.219E+07	0.	0.	6.404E+05	0	0	220	0
8	8	8	0.	1.822E+07	7.691E+05	0.	0.	1.210E+07	0.	0.	5.130E+05	0	0	220	0
9	9	9	0.	1.136E+07	6.404E+05	0.	0.	1.119E+07	0.	0.	2.433E+04	0	0	200	0
10	10	10	1.143E+05	5.941E+06	6.772E+05	0.	0.	1.172E+07	0.	2.492E+05	1.920E+04	0	14	156	0
11	11	11	2.323E+06	5.762E+05	5.070E+05	0.	0.	1.119E+07	0.	4.189E+06	0.	0	201	26	0
12	12	12	1.161E+07	0.	4.486E+05	0.	0.	1.119E+07	0.	1.117E+07	0.	0	609	0	0
FINAL			1.153E+07	9.187E+07	7.567E+06	0.	0.	1.402E+09	0.	4.611E+07	1.508E+06	0	2072	1494	0

	LOAD	=	1-5JIE+05 AT HOUR	8 ON DAY	8 OF MONTH	1 WITH A ZONE AIR TEMP OF 67.95
MAXIMUM HEATING						
MAXIMUM COMFORT LOAD =			1-294E+05 AT HOUR	16 ON DAY	1 OF MONTH	7 WITH A ZONE AIR TEMP OF 78.60
MAXIMUM ZONE AIR TEMP =			1-114E+02 AT HOUR	18 ON DAY	30 OF MONTH	
MAXIMUM ZONE AIR TEMP =			6-106E+01 AT HOUR	7 ON DAY	8 OF MONTH	

REFRIGERATION HEAT GAIN/LOSS REFERS TO SENSIBLE PORTION ONLY. LATENT PORTION IS COMBINED BY AIR HANDLING SYSTEM SUBPROGRAM. LOSS = MASS FLOW * SPECIFIC HEAT * (ZONE TEMP - OUTSIDE TEMP). IT IS INCLUDED IN TOTAL SENSIBLE LOAD.

20050 ACFT MSCH ENG

LOADS SUMMARY FIVE ZONE

01

SECOND FLOWN LEFT WING

WRIGHT PATTERSON AFB

WING	HEATING LOAD (BTU)	Cooling LOAD (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	HASERBOARD LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILT HEAT LOSS (BTU)	INFILT HEAT GAIN (BTU)	MAT/ H EX H	ODH/ H IN C IN	UMH/ C IN C EX
1	3.47E+07	0.	6.17E+05	0.	0.	1.55E+07	0.	2.1E+07	0.	0	725	0
2	2.88E+07	0.	5.67E+05	0.	0.	1.42E+07	0.	1.80E+07	0.	0	646	0
3	9.75E+06	1.29E+06	6.84E+05	0.	0.	1.49E+07	0.	6.16E+06	2.10E+03	0	394	39
4	1.70E+05	3.97E+06	8.73E+05	0.	0.	1.54E+07	0.	8.87E+05	0.	0	19	133
5	3.97E+03	7.90E+06	9.41E+05	0.	0.	1.55E+07	0.	5.19E+04	2.56E+04	0	1	194
6	0.	1.69E+07	9.00E+05	0.	0.	1.42E+07	0.	0.	4.04E+05	0	0	200
7	0.	2.18E+07	9.99E+05	0.	0.	1.55E+07	0.	0.	9.17E+05	0	0	220
8	0.	1.98E+07	9.93E+05	0.	0.	1.55E+07	0.	0.	7.21E+05	0	0	220
9	0.	1.05E+07	8.82E+05	0.	0.	1.42E+07	0.	0.	3.49E+04	0	0	194
10	1.34E+06	4.30E+06	8.13E+05	0.	0.	1.49E+07	0.	1.33E+06	2.82E+04	0	108	117
11	9.09E+06	2.39E+05	6.09E+05	0.	0.	1.42E+07	0.	8.41E+06	0.	0	467	14
12	2.79E+07	0.	5.65E+05	0.	0.	1.42E+07	0.	1.68E+07	0.	0	711	0
FINAL	1.00E+03	8.69E+07	9.44E+06	0.	0.	1.79E+08	0.	7.55E+07	2.13E+06	0	3071	1331

MAXIMUM HEATING LOAD = 2.30E+05 AT HOUR 8 ON DAY 8 OF MONTH 1 WITH A ZONE AIR TEMP OF 67.22
 MAXIMUM COOLING LOAD = 1.43E+05 AT HOUR 13 ON DAY 22 OF MONTH 7 WITH A ZONE AIR TEMP OF 78.63
 MAXIMUM ZONE AIR TEMP = 1.02E+02 AT HOUR 15 ON DAY 24 OF MONTH 8
 MINIMUM ZONE AIR TEMP = 6.13E+01 AT HOUR 7 ON DAY 8 OF MONTH 1

PERILTRATION HEAT GAIN/LOSS REFERS TO SENSIBLE PORTION ONLY.
 LATENT PORTION IS COMPUTED BY AIR HANDLING SYSTEM SUBPROGRAM.
 LOSS = MASS FLOW * SPECIFIC HEAT * (ZONE TEMP - OUTSIDE TEMP)
 IT IS INCLUDED IN TOTAL SENSIBLE LOAD.

20150 ACFT HSCU ENG

SECOND FLOOR NIGHT MO

78

LOADS SUMMARY FOR ZONE

RIGHT PATIENTS A F B

NO	DAY	HEATING LOAD (BTU)	Cooling LOAD (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	BASEBOARD LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILT HEAT LOSS (BTU)	INFILT HEAT GAIN (BTU)	MAT/ HEX H IN	QUB/ H IN C IN	C EX
1		2.71E+07	0.	6.23E+05	0.	0.	1.24E+07	0.	2.12E+07	0.	0	714	0
2		2.087E+07	0.	5.70E+05	0.	0.	1.137E+07	0.	1.64E+07	0.	0	626	0
3		7.57E+06	0.55E+05	6.73E+05	0.	0.	1.197E+07	0.	7.894E+06	2.719E+03	0	370	33
4		1.441E+05	2.61E+06	8.657E+05	0.	0.	1.239E+07	0.	8.10E+05	0.	0	16	121
5		0.	5.53E+06	9.36E+05	0.	0.	1.245E+07	0.	0.	2.76E+04	0	0	168
6		0.	1.31E+07	8.89E+05	0.	0.	1.142E+07	0.	0.	4.08E+05	0	0	200
7		0.	1.744E+07	9.84E+05	0.	0.	1.245E+07	0.	0.	9.093E+05	0	0	220
8		0.	1.62E+07	9.92E+05	0.	0.	1.245E+07	0.	0.	7.14E+05	0	0	220
9		0.	8.69E+06	9.77E+05	0.	0.	1.142E+07	0.	0.	3.81E+04	0	0	195
10		9.65E+05	3.54E+06	9.14E+05	0.	0.	1.197E+07	0.	1.027E+06	3.07E+04	0	84	117
11		7.155E+06	1.38E+05	6.06E+05	0.	0.	1.142E+07	0.	7.96E+06	0.	0	441	10
12		2.247E+07	0.	5.69E+05	0.	0.	1.14E+07	0.	1.57E+07	0.	0	706	0

FINAL										7.043E+07	2.131E+06	0	2961 1304

MAXIMUM HEATING LOAD = 2.08E+07 AT HOUR 8 ON DAY 8 OF MONTH 8 WITH A ZONE AIR TEMP OF 67.08
 MAXIMUM COOLING LOAD = 1.15E+07 AT HOUR 14 ON DAY 23 OF MONTH 8 WITH A ZONE AIR TEMP OF 76.10
 MAXIMUM ZONE AIR TEMP = 1.01E+02 AT HOUR 14 ON DAY 25 OF MONTH 8
 MINIMUM ZONE AIR TEMP = 6.15E+01 AT HOUR 18 ON DAY 4 OF MONTH 1

INFILTRATION HEAT GAIN/LOSS REFERS TO SENSIBLE PORTION ONLY.
 LATENT PORTION IS COMPLETED BY AIR HANDLING SYSTEM SUBPROGRAM.
 LOSS = MASS FLOW * SPECIFIC HEAT * (ZONE TEMP - OUTSIDE TEMP)
 IT IS INCLUDED IN TOTAL SENSIBLE LOAD.

20050 ACFT RSCH ENG

SECOND FLWR CENTRAL HQ

8X

LOADS SUMMARY FOR ZONE

MINUT PATTERNS A F R

MO	DAY	HEATING LOAD (BTU)	Cooling LOAD (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	BASEBOARD LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILTRATION HEAT LOSS (BTU)	INFILTRATION HEAT GAIN (BTU)	NATURAL HEAT EXCH (BTU)	COOLING HEAT EXCH (BTU)	COOLING HEAT EXCH (BTU)
1		2.372E+07	0.	4.849E+05	0.	0.	1.323E+07	0.	1.504E+07	0.	0	710	0
2		1.708E+07	0.	4.492E+05	0.	0.	1.298E+07	0.	1.214E+07	0.	0	602	0
3		5.166E+06	1.613E+06	5.523E+05	0.	0.	1.271E+07	0.	5.309E+06	1.854E+03	0	329	52
4		7.685E+03	5.515E+06	7.067E+05	0.	0.	1.317E+07	0.	1.381E+05	0.	0	3	172
5		0.	9.204E+06	7.307E+05	0.	0.	1.323E+07	0.	0.	1.999E+04	0	0	212
6		0.	1.628E+07	6.908E+05	0.	0.	1.214E+07	0.	0.	3.036E+05	0	0	200
7		0.	1.999E+07	7.630E+05	0.	0.	1.323E+07	0.	0.	6.819E+05	0	0	220
8		0.	1.833E+07	7.607E+05	0.	0.	1.323E+07	0.	0.	5.379E+05	0	0	220
9		0.	1.053E+07	6.908E+05	0.	0.	1.214E+07	0.	0.	2.833E+04	0	0	200
10		6.163E+05	4.821E+06	6.524E+05	0.	0.	1.271E+07	0.	5.701E+05	2.250E+04	0	81	141
11		5.375E+06	3.767E+05	4.866E+05	0.	0.	1.214E+07	0.	5.302E+06	0.	0	414	19
12		1.915E+07	0.	4.442E+05	0.	0.	1.214E+07	0.	1.167E+07	0.	0	697	0
FINAL		7.121E+07	8.612E+07	7.413E+06	0.	0.	1.521E+08	0.	5.020E+07	1.596E+06	0	2936	1436

MAXIMUM HEATING LOAD = 1.632E+05 AT HOUR 8 ON DAY 8 OF MONTH 1 WITH A ZONE AIR TEMP OF 68.03
 MAXIMUM COOLING LOAD = 1.279E+05 AT HOUR 16 ON DAY 1 OF MONTH 7 WITH A ZONE AIR TEMP OF 78.16
 MAXIMUM ZONE AIR TEMP = 1.091E+02 AT HOUR 16 ON DAY 21 OF MONTH 7
 MINIMUM ZONE AIR TEMP = 6.163E+01 AT HOUR 7 ON DAY 8 OF MONTH 1

INFILTRATION HEAT GAIN/LOSS REFERS TO SENSIBLE PORTION ONLY.
 LATENT PORTION IS COMPUTED BY AIR HANDLING SYSTEM SUPPLEMENT.
 LOSS = MASS FLOW * SPECIFIC HEAT * (ZONE TEMP - OUTSIDE TEMP)
 IF IS INCLUDED IN TOTAL SENSIBLE LOAD.

 ** AIR HANDLING SYSTEM ENERGY USE SUMMARY **
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PROJECT: ENERGY ANALYSIS OF BUILDING 20050

SYSTEM NUMBER = 1 SYSTEM LOCATION = 13040 SIMULATION PERIOD = 1/1/1968 - 12/30/1968
 SYSTEM NAME = MULTIZONE FAN SYSTEM SYSTEM TYPE = MULTIZONE

ELECTRICITY

MONTH	BUILDING LIGHTS CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	FANS CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	CONSUMPTION (BTU)	HEATING CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	CONSUMPTION (BTU)	TOTAL USE CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)
JAN	5.350E+07	1.450E+05	7.555E+06	1.015E+04	0.	0.	0.	6.106E+07	1.552E+05	1.552E+05
FEB	4.944E+07	1.450E+05	7.068E+06	1.015E+04	0.	0.	0.	5.051E+07	1.552E+05	1.552E+05
MAR	5.245E+07	1.450E+05	6.611E+06	1.015E+04	0.	0.	0.	5.906E+07	1.552E+05	1.552E+05
APR	5.252E+07	1.450E+05	5.595E+06	1.015E+04	0.	0.	0.	5.812E+07	1.552E+05	1.552E+05
MAY	5.350E+07	1.450E+05	5.605E+06	1.015E+04	0.	0.	0.	5.911E+07	1.552E+05	1.552E+05
JUN	5.042E+07	1.450E+05	4.874E+06	1.015E+04	0.	0.	0.	5.530E+07	1.552E+05	1.552E+05
JUL	5.350E+07	1.450E+05	5.605E+06	1.015E+04	0.	0.	0.	5.911E+07	1.552E+05	1.552E+05
AUG	5.350E+07	1.450E+05	5.362E+06	1.015E+04	0.	0.	0.	5.817E+07	1.552E+05	1.552E+05
SEP	5.042E+07	1.450E+05	5.111E+06	1.015E+04	0.	0.	0.	5.554E+07	1.552E+05	1.552E+05
OCT	5.245E+07	1.450E+05	5.605E+06	1.015E+04	0.	0.	0.	5.806E+07	1.552E+05	1.552E+05
NOV	5.042E+07	1.450E+05	5.595E+06	1.015E+04	0.	0.	0.	5.802E+07	1.552E+05	1.552E+05
DEC	5.012E+07	1.450E+05	7.312E+06	1.015E+04	0.	0.	0.	5.773E+07	1.552E+05	1.552E+05
ANNUAL	6.220E+08	1.450E+05	7.191E+07	1.015E+04	0.	0.	0.	6.945E+08	1.552E+05	1.552E+05

CYREP - R.L.A.S.T. --		VERSION 2.0		LVL 100.05	22 JUL 81	19.13.05.	PAGE 45	
MONTH	G A S		S T E A M		H O T W A T E R		C H I L L E D W A T E R	
	TOTAL USE CONSUMPTION (RTU)	PEAK DEMAND (RTU/HR)	TOTAL USE CONSUMPTION (RTU)	PEAK DEMAND (RTU/HR)	TOTAL USE CONSUMPTION (RTU)	PEAK DEMAND (RTU/HR)	TOTAL USE CONSUMPTION (RTU)	PEAK DEMAND (RTU/HR)
JAN	0.	0.	6.747E+07	3.565E+05	0.	0.	0.	0.
FEB	0.	0.	5.646E+07	3.107E+05	0.	0.	0.	0.
MAR	0.	0.	2.290E+07	2.814E+05	0.	0.	0.	0.
APR	0.	0.	6.773E+06	7.997E+04	0.	0.	0.	0.
MAY	0.	0.	4.104E+06	5.205E+04	0.	0.	0.	0.
JUN	0.	0.	0.	0.	0.	0.	3.752E+07	3.261E+05
JUL	0.	0.	0.	0.	0.	0.	5.597E+07	3.723E+05
AUG	0.	0.	0.	0.	0.	0.	5.182E+07	3.948E+05
SEP	0.	0.	0.	0.	0.	0.	2.420E+07	2.151E+05
OCT	0.	0.	7.125E+06	8.595E+04	0.	0.	0.	0.
NOV	0.	0.	1.524E+07	1.727E+05	0.	0.	0.	0.
DEC	0.	0.	5.090E+07	2.844E+05	0.	0.	0.	0.
ANN	0.	0.	2.311E+08	3.565E+05	0.	0.	1.694E+08	3.948E+05

 ** AIR HANDLING SYSTEM COMPONENT LOAD SUMMARY **

PROJECT ENERGY ANALYSIS OF BUILDING 20050

SIMULATION PERIOD = 1/1/1968 - 12/30/1968

SYSTEM LOCATION = 13040

SYSTEM NUMBER = 1

SYSTEM NAME = MULTIZONE FAN SYSTEM

SYSTEM TYPE = MULTIZONE

HEATING COIL LOADS

MONTH	CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	HRS CHSMPN (HOURS)	PK CAP EXCD (BTU/HR)	HRS CAP EXCD (HOURS)
JAN	6.747E+07	3.565E+05	744.	0.	0.
FEB	5.646E+07	3.107E+05	696.	0.	0.
MAR	2.290E+07	2.014E+05	619.	0.	0.
APR	6.773E+06	7.997E+04	486.	0.	0.
MAY	4.106E+06	5.205E+04	409.	0.	0.
JUN	0.	0.	0.	0.	0.
JUL	0.	0.	0.	0.	0.
AUG	0.	0.	0.	0.	0.
SEP	7.125E+06	8.555E+04	418.	0.	0.
OCT	1.524E+07	1.727E+05	537.	0.	0.
NOV	5.099E+07	2.844E+05	720.	0.	0.
DEC					
ANN	2.311E+09	3.565E+05	4628.	0.	0.

COOLING COIL LOADS

MONTH	CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	HRS CHSMPN (HOURS)	PK CAP EXCD (BTU/HR)	HRS CAP EXCD (HOURS)
JAN	0.	0.	0.	0.	0.
FEB	0.	0.	0.	0.	0.
MAR	0.	0.	0.	0.	0.
APR	0.	0.	0.	0.	0.
MAY	0.	0.	0.	0.	0.
JUN	3.752E+07	3.261E+05	474.	0.351E+04	26.
JUL	5.587E+07	3.723E+05	551.	1.097E+05	73.
AUG	5.182E+07	3.949E+05	521.	1.322E+05	81.
SEP	2.420E+07	2.151E+05	495.	0.	0.
OCT	0.	0.	0.	0.	0.
NOV	0.	0.	0.	0.	0.
DEC	0.	0.	0.	0.	0.
ANN	1.604E+09	3.949E+05	2041.	1.322E+05	180.

 ** AIR HANDLING SYSTEM ENERGY USE SUMMARY **
 **

PROJECT: ENERGY ANALYSIS OF BUILDING 20050

SYSTEM NUMBER = 2 SYSTEM LOCATION = 13640 SIMULATION PERIOD = 1/1/1960 - 12/30/1968
 SYSTEM NAME = MULTIZONE FAN SYSTEM 2 SYSTEM TYPE = MULTIZONE

ELECTRICITY

MONTH	BUILDING LIGHTS		FANS		HEATING		TOTAL USE	
	CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	CONSUMPTION (RTU)	PEAK DEMAND (RTU/HR)	CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)
JAN	4.350E+07	1.690E+05	1.200E+07	1.857E+04	0.	0.	5.650E+07	1.866E+05
FEB	3.970E+07	1.690E+05	1.180E+07	1.857E+04	0.	0.	5.167E+07	1.866E+05
MAR	4.190E+07	1.690E+05	1.000E+07	1.857E+04	0.	0.	5.190E+07	1.866E+05
APR	4.330E+07	1.690E+05	9.803E+06	1.857E+04	0.	0.	5.310E+07	1.866E+05
MAY	4.350E+07	1.690E+05	1.025E+07	1.857E+04	0.	0.	5.303E+07	1.866E+05
JUN	3.090E+07	1.690E+05	8.912E+06	1.857E+04	0.	0.	4.890E+07	1.866E+05
JUL	4.350E+07	1.690E+05	1.025E+07	1.857E+04	0.	0.	5.303E+07	1.866E+05
AUG	4.350E+07	1.690E+05	9.803E+06	1.857E+04	0.	0.	5.330E+07	1.866E+05
SEP	3.090E+07	1.690E+05	9.350E+06	1.857E+04	0.	0.	4.934E+07	1.866E+05
OCT	4.180E+07	1.690E+05	1.025E+07	1.857E+04	0.	0.	5.213E+07	1.866E+05
NOV	3.090E+07	1.690E+05	9.233E+06	1.857E+04	0.	0.	4.992E+07	1.866E+05
DEC	3.090E+07	1.690E+05	1.311E+07	1.857E+04	0.	0.	5.309E+07	1.866E+05
YR	5.012E+09	1.690E+05	1.266E+09	1.857E+04	0.	0.	6.270E+09	1.866E+05

MONTH	G A S			S T E A M			H O T W A T E R			C H I L L E D W A T E R		
	CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	TOTAL USE (BTU)	CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	TOTAL USE (BTU)	CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	TOTAL USE (BTU)	CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	TOTAL USE (BTU)
JAN	0.	0.	9.745E+07	6.645E+05	0.	0.	0.	0.	0.	0.	0.	0.
FEB	0.	0.	6.739E+07	5.481E+05	0.	0.	0.	0.	0.	0.	0.	0.
MAR	0.	0.	2.474E+07	4.000E+05	0.	0.	0.	0.	0.	0.	0.	0.
APR	0.	0.	9.586E+06	5.067E+04	0.	0.	0.	0.	0.	0.	0.	0.
MAY	0.	0.	6.037E+06	5.339E+04	0.	0.	0.	0.	0.	0.	0.	0.
JUN	0.	0.	0.	0.	0.	0.	7.357E+07	6.533E+05	0.	0.	0.	0.
JUL	0.	0.	0.	0.	0.	0.	1.024E+08	6.972E+05	0.	0.	0.	0.
AUG	0.	0.	0.	0.	0.	0.	9.517E+07	7.174E+05	0.	0.	0.	0.
SEP	0.	0.	0.	0.	0.	0.	4.927E+07	4.547E+05	0.	0.	0.	0.
OCT	0.	0.	9.751E+06	1.605E+05	0.	0.	0.	0.	0.	0.	0.	0.
NOV	0.	0.	2.201E+07	2.789E+05	0.	0.	0.	0.	0.	0.	0.	0.
DEC	0.	0.	6.991E+07	4.496E+05	0.	0.	0.	0.	0.	0.	0.	0.
ANNUAL	0.	0.	2.969E+08	6.645E+05	0.	0.	3.204E+08	7.174E+05	0.	0.	0.	0.

 ** AIR HANDLING SYSTEM ENERGY USE SUMMARY **
 ** *****

PROJECT: ENERGY ANALYSIS OF BUILDING 20050

SYSTEM NUMBER = 3 SYSTEM LOCATION = 13840 SIMULATION PERIOD = 1/ 1/1968 - 12/30/1968
 SYSTEM NAME = MULTIZONE FAN SYSTEM 3 SYSTEM TYPE = MULTIZONE

E L E C T R I C I T Y

MONTH	BUILDING LIGHTS		FANS		HEATING		TOTAL USE	
	CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)
JAN	4.124E+07	1.590E+05	1.679E+07	2.269E+04	0.	0.	5.803E+07	1.817E+05
FEB	3.765E+07	1.590E+05	1.524E+07	2.269E+04	0.	0.	5.291E+07	1.817E+05
MAR	3.964E+07	1.590E+05	1.413E+07	2.269E+04	0.	0.	5.377E+07	1.817E+05
APR	4.105E+07	1.590E+05	1.206E+07	2.269E+04	0.	0.	5.312E+07	1.817E+05
MAY	4.124E+07	1.590E+05	1.252E+07	2.269E+04	0.	0.	5.376E+07	1.817E+05
JUN	3.784E+07	1.590E+05	1.089E+07	2.269E+04	0.	0.	4.873E+07	1.817E+05
JUL	4.124E+07	1.590E+05	1.252E+07	2.269E+04	0.	0.	5.376E+07	1.817E+05
AUG	4.124E+07	1.590E+05	1.197E+07	2.269E+04	0.	0.	5.322E+07	1.817E+05
SEP	3.784E+07	1.590E+05	1.143E+07	2.269E+04	0.	0.	4.927E+07	1.817E+05
OCT	3.964E+07	1.590E+05	1.311E+07	2.269E+04	0.	0.	5.275E+07	1.817E+05
NOV	3.744E+07	1.590E+05	1.447E+07	2.269E+04	0.	0.	5.231E+07	1.817E+05
DEC	3.784E+07	1.590E+05	1.633E+07	2.269E+04	0.	0.	5.417E+07	1.817E+05
ANN	4.131E+09	1.590E+05	1.615E+09	2.269E+04	0.	0.	6.359E+09	1.817E+05

 ** AIR HANDLING SYSTEM COMPONENT LOAD SUMMARY **
 **

PROJECT: ENERGY ANALYSIS OF BUILDING 20050

SYSTEM NUMBER = 2 SYSTEM LOCATION = 13040 SIMULATION PERIOD = 1/1/1968 - 12/30/1968
 SYSTEM NAME = MULTIZONE FAN SYSTEM 2 SYSTEM TYPE = MULTIZONE

HEATING COIL LOADS

MONTH	CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	INHS CONSUMPT (HHNS)	PK CAP EXCD (RTU/HR)	INHS CAP EXCD (HHNS)
JAN	8.745E+07	6.645E+05	699.	0.	0.
FEB	6.739E+07	5.491E+05	640.	0.	0.
MAR	2.474E+07	4.090E+05	483.	0.	0.
APR	9.594E+06	5.067E+04	367.	0.	0.
MAY	6.037E+06	5.339E+04	287.	0.	0.
JUN	0.	0.	0.	0.	0.
JUL	0.	0.	0.	0.	0.
AUG	0.	0.	0.	0.	0.
SEP	0.	0.	0.	0.	0.
OCT	9.751E+06	1.665E+05	375.	0.	0.
NOV	2.201E+07	2.789E+05	515.	0.	0.
DEC	6.991E+07	4.496E+05	706.	0.	0.
ANN	2.969E+08	6.645E+05	4072.	0.	0.

Cooling Coil Loads

MONTH	CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	INHS CONSUMPT (HHNS)	PK CAP EXCD (RTU/HR)	INHS CAP EXCD (HHNS)
JAN	0.	0.	0.	0.	0.
FEB	0.	0.	0.	0.	0.
MAR	0.	0.	0.	0.	0.
APR	0.	0.	0.	0.	0.
MAY	0.	0.	0.	0.	0.
JUN	7.357E+07	6.513E+05	423.	1.657E+05	28.
JUL	1.024E+08	6.672E+05	521.	2.094E+05	80.
AUG	9.517E+07	7.174E+05	452.	2.298E+05	76.
SEP	4.927E+07	4.547E+05	359.	0.	0.
OCT	0.	0.	0.	0.	0.
NOV	0.	0.	0.	0.	0.
DEC	0.	0.	0.	0.	0.
ANN	3.204E+08	7.174E+05	1755.	2.398E+05	184.

 ** AIR HANDLING SYSTEM ENERGY USE SUMMARY **
 **

PROJECT: ENERGY ANALYSIS OF BUILDING 20050

SYSTEM NUMBER = 3 SYSTEM LOCATION = 13040 SIMULATION PERIOD = 1/1/1968 - 12/30/1968
 SYSTEM NAME = MULTIZONE FAN SYSTEM 3 SYSTEM TYPE = MULTIZONE

MONTH	ELECTRICITY				HEATING		TOTAL USE	
	BUILDING LIGHTS CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	FANS CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)	CONSUMPTION (BTU)	PEAK DEMAND (BTU/HR)
JAN	4.124E+07	1.590E+05	1.670E+07	2.269E+04	0.	0.	5.803E+07	1.817E+05
FEB	3.765E+07	1.590E+05	1.526E+07	2.269E+04	0.	0.	5.291E+07	1.817E+05
MAR	3.964E+07	1.590E+05	1.413E+07	2.269E+04	0.	0.	5.377E+07	1.817E+05
APR	4.105E+07	1.590E+05	1.206E+07	2.269E+04	0.	0.	5.312E+07	1.817E+05
MAY	4.124E+07	1.590E+05	1.252E+07	2.269E+04	0.	0.	5.376E+07	1.817E+05
JUN	3.784E+07	1.590E+05	1.089E+07	2.269E+04	0.	0.	4.873E+07	1.817E+05
JUL	4.124E+07	1.590E+05	1.252E+07	2.269E+04	0.	0.	5.376E+07	1.817E+05
AUG	4.124E+07	1.590E+05	1.197E+07	2.269E+04	0.	0.	5.322E+07	1.817E+05
SEP	3.784E+07	1.590E+05	1.143E+07	2.269E+04	0.	0.	4.927E+07	1.817E+05
OCT	3.964E+07	1.590E+05	1.311E+07	2.269E+04	0.	0.	5.275E+07	1.817E+05
NOV	3.744E+07	1.590E+05	1.447E+07	2.269E+04	0.	0.	5.231E+07	1.817E+05
DEC	3.784E+07	1.590E+05	1.633E+07	2.269E+04	0.	0.	5.417E+07	1.817E+05
ANN	4.124E+07	1.590E+05	1.615E+07	2.269E+04	0.	0.	6.359E+07	1.817E+05

CYBER -- H.I.A.S.T. ---		VERSION 2.0		LVL 100.05		22 JUL 81		19.13.05.		PAGE 56		
MONTH	G A S			S T E A M			H O T W A T E R			C H I L L E D W A T E R		
	CONSUMPTION (BTU)	TOTAL USE PEAK DEMAND (BTU/HR)	CONSUMPTION (BTU)	TOTAL USE PEAK DEMAND (BTU/HR)	CONSUMPTION (BTU)	TOTAL USE PEAK DEMAND (BTU/HR)	CONSUMPTION (BTU)	TOTAL USE PEAK DEMAND (BTU/HR)	CONSUMPTION (BTU)	TOTAL USE PEAK DEMAND (BTU/HR)	CONSUMPTION (BTU)	TOTAL USE PEAK DEMAND (BTU/HR)
JAN	0.	0.	1.285E+08	7.406E+05	0.	0.	0.	0.	0.	0.	0.	0.
FEB	0.	0.	1.032E+08	6.132E+05	0.	0.	0.	0.	0.	0.	0.	0.
MAR	0.	0.	4.201E+07	4.619E+05	0.	0.	0.	0.	0.	0.	0.	0.
APR	0.	0.	1.086E+07	8.752E+04	0.	0.	0.	0.	0.	0.	0.	0.
MAY	0.	0.	6.765E+06	6.170E+04	0.	0.	0.	0.	0.	0.	0.	0.
JUN	0.	0.	0.	0.	0.	0.	0.	0.	7.114E+07	6.184E+05	0.	0.
JUL	0.	0.	0.	0.	0.	0.	0.	0.	1.018E+08	7.063E+05	0.	0.
AUG	0.	0.	0.	0.	0.	0.	0.	0.	9.416E+07	7.074E+05	0.	0.
SEP	0.	0.	0.	0.	0.	0.	0.	0.	4.284E+07	4.363E+05	0.	0.
OCT	0.	0.	1.312E+07	2.151E+05	0.	0.	0.	0.	0.	0.	0.	0.
NOV	0.	0.	3.785E+07	3.233E+05	0.	0.	0.	0.	0.	0.	0.	0.
DEC	0.	0.	1.032E+08	4.965E+05	0.	0.	0.	0.	0.	0.	0.	0.
ANN	0.	0.	4.455E+08	7.406E+05	0.	0.	0.	0.	3.100E+08	7.074E+05	0.	0.

AIR HANDLING SYSTEM COMPONENT LOAD SUMMARY

SUBJECT: ENERGY ANALYSIS OF BUILDING 20050

SYSTEM NUMBER =	3	SYSTEM LOCATION =	1340	SIMULATION PERIOD =	1/1/1969 - 12/30/1969
SYSTEM NAME =	MULTIZONE FAN SYSTEM 3	SYSTEM TYPE =	MULTIZONE		
MONTH	CONSUMPTION (BTU)	PEAK DEMAND (RTU/HR)	HWS CYCSMPT (HRS)	PK CAP EXCD (BTU/HR)	HWS CAP EXCD (HRS)
JAN	1.205E+08	7.404E+05	740.	0.	0.
FEB	1.032E+08	6.132E+05	665.	0.	0.
MAR	4.201E+07	4.819E+05	574.	0.	0.
APR	1.094E+07	9.752E+04	424.	0.	0.
MAY	6.765E+06	6.170E+04	343.	0.	0.
JUN	0.	0.	0.	0.	0.
JUL	0.	0.	0.	0.	0.
AUG	0.	0.	0.	0.	0.
SEP	0.	0.	0.	0.	0.
OCT	1.312E+07	2.151E+05	442.	0.	0.
NOV	3.745E+07	3.233E+05	611.	0.	0.
DEC	1.032E+08	4.905E+05	720.	0.	0.
ANN	4.455E+08	7.404E+05	4523.	0.	0.
JAN	0.	0.	0.	0.	0.
FEB	0.	0.	0.	0.	0.
MAR	0.	0.	0.	0.	0.
APR	0.	0.	0.	0.	0.
MAY	0.	0.	0.	0.	0.
JUN	7.114E+07	6.184E+05	418.	1.821E+04	4.
JUL	1.018E+08	7.063E+05	510.	1.062E+05	16.
AUG	9.416E+07	7.074E+05	444.	1.072E+05	14.
SEP	4.284E+07	4.363E+05	369.	0.	0.
OCT	0.	0.	0.	0.	0.
NOV	0.	0.	0.	0.	0.
DEC	0.	0.	0.	0.	0.
ANN	3.100E+09	7.074E+05	4740.	1.072E+05	34.

TIME OF DAY ELECTRICAL USAGE REPORT

PROJECT'S ENERGY ANALYSIS OF BUILDING 20050

PLANT NUMBER = 1 PLANT LOCATION = 13840 SIMULATION PERIOD = 1/1/1968 - 12/30/1968

PLANT NAME = CENTRAL PLANT SYSTEM 1

MONTH	RATE 1 (KWH)	DEMAND 1 (KW)	RATE 2 (KWH)	DEMAND 2 (KW)	RATE 3 (KWH)	DEMAND 3 (KW)	RATE 4 (KWH)	DEMAND 4 (KW)	RATE 5 (KWH)	DEMAND 5 (KW)
1	0.	0.	0.	0.	4.2626E+04	1.5540E+02	1.0384E+04	5.0784E+01	0.	0.
2	0.	0.	0.	0.	3.8924E+04	1.5540E+02	9.7229E+03	5.0784E+01	0.	0.
3	0.	0.	0.	0.	3.9925E+04	1.5540E+02	9.6506E+03	5.0784E+01	0.	0.
4	0.	0.	0.	0.	4.0108E+04	1.5540E+02	9.0711E+03	1.5540E+02	0.	0.
5	0.	0.	0.	0.	3.7912E+04	1.5540E+02	1.1773E+04	1.5540E+02	0.	0.
6	3.5734E+04	2.9340E+02	3.9082E+04	2.9496E+02	0.	0.	0.	0.	0.	0.
7	4.0057E+04	3.0296E+02	4.5211E+04	3.0501E+02	0.	0.	0.	0.	0.	0.
8	3.9981E+04	2.9482E+02	4.3805E+04	3.0472E+02	0.	0.	0.	0.	0.	0.
9	3.4416E+04	2.6364E+02	3.8620E+04	2.5616E+02	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	3.7255E+04	1.5540E+02	1.1419E+04	1.5540E+02	0.	0.
11	0.	0.	0.	0.	3.8397E+04	1.5540E+02	9.2539E+03	5.0784E+01	0.	0.
12	0.	0.	0.	0.	3.9823E+04	1.5540E+02	1.0019E+04	5.0784E+01	0.	0.
ANN	1.4012E+05	3.0296E+02	1.6733E+05	3.0501E+02	3.1497E+05	1.5540E+02	8.1202E+04	1.5540E+02	0.	0.

 ** EQUIPMENT USE STATISTICS **
 ** *****

PROJECT: ENERGY ANALYSIS OF BUILDING 20050

PLANT NUMBER = 1 PLANT LOCATION = 13040 SIMULATION PERIOD = 1/1/68 - 12/30/1968

PLANT NAME = CENTRAL PLANT SYSTEM 1

EQUIPMENT										
AVG OPER RATIO	MAX LOAD (KBTU/H)	MIN DY	HR	SIZE (KBTU/H)	OPEN HOURS	SIZE (KBTU/H)	OPEN HOURS	SIZE (KBTU/H)	OPEN HOURS	
.137	1200.	12 24 10		1200.	6578					
.271	1728.	8 23 7		1440.	2050					
UTILITY ENERGY										
1-YR UNADJ COST (K\$)	1-YEAR USAGE (KBTU)	PEAK USAGE (KBTU/H)		COST ESCALATION FACTOR						
41.5	2.439	1041.4		0.000						
13.9	1.851	1468.5		0.000						
9										
UTILITY ENERGY TOTAL										
95.4										

 ** TIME OF DAY ELECTRICAL USAGE REPORT **
 ** *****

PROJECT: ENERGY ANALYSIS OF BUILDING 20050

PLANT NUMBER = 2 PLANT LOCATION = 13040 SIMULATION PERIOD = 1/1/1968 - 12/30/1968
 PLANT NAME = COLD STORAGE CHILLER 12 MINR OPERATION

211

MONTH	RATE 1 (KWH)	DEMAND 1 (KW)	RATE 2 (KWH)	DEMAND 2 (KW)	RATE 3 (KWH)	DEMAND 3 (KW)	RATE 4 (KWH)	DEMAND 4 (KW)	RATE 5 (KWH)	DEMAND 5 (KW)
1	0.	0.	0.	0.	4.2626E+04	1.5540E+02	1.0384E+04	5.0784E+01	0.	0.
2	0.	0.	0.	0.	3.8924E+04	1.5540E+02	9.7229E+03	5.0784E+01	0.	0.
3	0.	0.	0.	0.	3.9925E+04	1.5540E+02	9.6506E+03	5.0784E+01	0.	0.
4	0.	0.	0.	0.	4.0108E+04	1.5540E+02	9.0711E+03	1.5540E+02	0.	0.
5	0.	0.	0.	0.	3.7912E+04	1.5540E+02	1.1773E+04	1.5540E+02	0.	0.
6	2.7209E+04	1.8872E+02	4.1646E+04	2.8902E+02	0.	0.	0.	0.	0.	0.
7	2.9418E+04	1.3812E+02	4.7646E+04	2.8807E+02	0.	0.	0.	0.	0.	0.
8	2.9314E+04	1.8872E+02	4.6120E+04	2.8675E+02	0.	0.	0.	0.	0.	0.
9	2.7275E+04	1.8872E+02	1.6624E+04	2.4374E+02	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	3.7256E+04	1.5540E+02	1.1419E+04	1.5540E+02	0.	0.
11	0.	0.	0.	0.	3.4397E+04	1.5540E+02	9.2530E+03	5.0784E+01	0.	0.
12	0.	0.	0.	0.	3.9123E+04	1.5540E+02	1.0819E+04	5.0784E+01	0.	0.
AVG	1.1336E+05	1.8872E+02	1.7224E+05	2.8902E+02	3.1497E+05	1.5540E+02	8.1202E+04	1.5540E+02	0.	0.

 ** C H I L L E D A N D H O T W A T E R L O A D S N O T R E P O R T **
 **

PROJECT: ENERGY ANALYSIS OF BUILDING 20050

SIMULATION PERIOD = 1/1/1968 - 12/30/1968

PLANT LOCATION = 13840

2

PLANT NUMBER =

PLANT NAME = CHLD STORAGE CHILLER 12 HOUR OPERATION

212

MONTH	HOT WATER (BTU)	CHILLED WATER (BTU)
1	.3659E+07	0.
2	.6259E+06	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	.6211E-08
8	0.	.6211E-09
9	0.	0.
10	0.	0.
11	0.	0.
12	.3549E+05	0.
ANN	4.3114E+06	1.5422E-03

TIME OF DAY ELECTRICAL USAGE REPORT

PROJECT: ENERGY ANALYSIS OF BUILDING 20050

SIMULATION PERIOD = 1/1/1968 - 12/30/1968

PLANT LOCATION - 13840

PLANT NAME - CIND STORAGE CHILLER 24 HOUR OPERATION

POINT	RATE 1 (KWH)	DEMAND 1 (KW)	RATE 2 (KWH)	DEMAND 2 (KW)	RATE 3 (KWH)	DEMAND 3 (KW)	RATE 4 (KWH)	DEMAND 4 (KW)	RATE 5 (KWH)	DEMAND 5 (KW)
1	0.	0.	0.	0.	4.2626E+04	1.5540E+02	1.0794E+04	5.0784E+01	0.	0.
2	0.	0.	0.	0.	3.8924E+04	1.5540E+02	0.7229E+03	5.0784E+01	0.	0.
3	0.	0.	0.	0.	3.9925E+04	1.5540E+02	9.6506E+03	5.0784E+01	0.	0.
4	0.	0.	0.	0.	4.0108E+04	1.5540E+02	9.0711E+03	1.5540E+02	0.	0.
5	0.	0.	0.	0.	3.7912E+04	1.5540E+02	1.1773E+04	1.5540E+02	0.	0.
6	1.3045E+04	2.3366E+02	3.6196E+04	2.3331E+02	0.	0.	0.	0.	0.	0.
7	1.1439E+04	2.3256E+02	1.9103E+04	2.2965E+02	0.	0.	0.	0.	0.	0.
8	1.6136E+04	2.3177E+02	3.0435E+04	2.3066E+02	0.	0.	0.	0.	0.	0.
9	1.0622E+04	2.2919E+02	3.2834E+04	2.3201E+02	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	3.7759E+04	1.5540E+02	1.1419E+04	1.5540E+02	0.	0.
11	0.	0.	0.	0.	3.9407E+04	1.5540E+02	9.2539E+03	5.0784E+01	0.	0.
12	0.	0.	0.	0.	3.9323E+04	1.5540E+02	1.0919E+04	5.0784E+01	0.	0.
13	1.1224E+04	2.3166E+02	1.4657E+04	2.3306E+02	3.1327E+04	1.5540E+02	9.1203E+03	1.5540E+02	0.	0.

 ** CHILLED AND HOT WATER LOADS NOT MET REPORT **
 ** *****

PROJECT: ENERGY ANALYSIS OF BUILDING 2050

SIMULATION PERIOD = 1/1/1968 - 12/30/1968

PLANT LOCATION = 13840

3

PLANT NUMBER =

PLANT NAME = CYRD STORAGE CHILLER 24 HOUR OPERATION

214

WPI#	HOT WATER (RTU)	CHILLED WATER (RTU)
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	.7591E+06
7	0.	.3235E+07
8	0.	.3647E+07
9	0.	.0521E+07
10	0.	0.
11	0.	0.
12	0.	0.
TOTAL	0.	7.6414E+06

 **
 ** EQUIPMENT USE STATISTICS
 **

PROJECT: ENERGY ANALYSIS OF BUILDING 2005A

PLANT NUMBER = 3 PLANT LOCATION = 13840 SIMULATION PERIOD = 1/1/1968 - 12/30/1968
 PLANT NAME = COLD STORAGE CHILLER 24 HOUR OPERATION

EQUIPMENT	AVG OPER RATIO	MAX LOAD (KBTUH)	HW DY	IR	SIZE (KBTUH)	OPER HOURS	SIZE (KBTUH)	OPER HOURS
STEAM BOILER	.137	1200.	12 24 10		1200.	6578		
RECIPROCATING CHILLER	.538	720.	9 24 16		720.	2119		
COLD WATER TANK	0.000	0.	0 0 0		11000.	0		
UTILITY, ENERGY								
	1YR UNADJ COST (K\$)	1-YEAR USAGE (GRTU)	PEAK USAGE (KBTUH)	COST ESCALATION FACTOR				
ELFCT	39.5	2.324	794.1	0.000				
BOILER	13.9	1.851	1694.5	0.000				
UTILITY, ENERGY TOTAL					53.4			

APPENDIX E
UNSTEADY-STATE HEAT GAIN BY
COLD STORAGE TANKS

The purpose of this appendix is to examine the amount of temperature rise in a chilled-water storage tank. The equations and calculations in the appendix are based on an article by J. D. Paciotti in the June 2, 1980 edition of Chemical Engineering. The article was titled "Unsteady State Heat Loss from Storage Tanks," and was intended as a decision aid in determining the amount of heating or insulation needed for storage tanks (20:104).

The unsteady state heat flow balance for a storage tank, assuming that U_0 and C_{p0} are constant over the temperature range in question, can be represented as:

$$mC_{p0} T/t + t - mC_{p0} T/t = 0 - U_0 A_0 (T - T_a) \Delta T \quad (1)$$

where:

T_a = temperature of outside air, °F

T_0 = tank fluid temperature at time 0, °F

T = tank fluid temperature at time t , °F

U_0 = overall heat-transfer coefficient based on T_0 , BTU/ft² Hr °F

A_0 = tank surface area upon which U_0 is based, ft²

m = mass of the fluid in the tank, lb

C_{p0} = heat capacity of the fluid at T_0 , BTU/lb °F

Energy accumulation in time t = energy in - energy out

Letting $\Delta t \rightarrow 0$, and rearranging, eq (1)

becomes

$$\frac{-m C_{po}}{U_o A_o} \frac{dT}{T-T_a} = dt \quad (2)$$

Integrating equation two yields:

$$\frac{-m C_{po}}{U_o A_o} \int_{T_o}^T \frac{dT}{T-T_a} = \int_0^t dt \quad (3)$$

the result is the time/temperature relationship
for a storage tank:

$$\frac{-m C_{po}}{U_o A_o} \ln \left(\frac{T-T_a}{T_o-T_a} \right) = t \quad (4)$$

taking the inverse \log_n of equation 4 and rearranging
terms yields:

$$T = (T_o - T_a) e^{-t \left(\frac{U_o A_o}{m C_{po}} \right)} + T_a$$

The storage tanks for the simulations on Building 20040 and 20050 are assumed to be insulated cylindrical tanks constructed of concrete with an $R = 20$. The tanks have an aspect ratio (height/diameter) of two and are buried below the ground. Ground temperatures represent T_a . The cooling capacity of the tanks are based on entering chilled water temperature of 44°F and return water temperature from air-handlers of 56°F.

A conversion value of 62.42 pounds of water at 60°F/cubic foot was used to calculate the relationships between cooling capacity, volume, and tank area as follows:

$$Q = m C_{po} \Delta T$$

$$m = \frac{Q}{C_{po} \Delta T}$$

Volume of the cylinder with aspect ratio of two is calculated:

$$\frac{h}{d} = 2 \text{ therefore}$$

$$h = 4r$$

$$V = 4\pi r^3$$

$$r = \sqrt[3]{V/4\pi}$$

$$r = \sqrt[3]{\frac{m/62.42}{4\pi}}$$

Area of the cylinder is calculated using:

$$A = 10 \pi r^2$$

Table 16 is developed using the equations and values presented above and the cooling capacities required by the simulations. The value of (T) is calculated assuming a value of t = 12 hours.

TABLE 16

THERMODYNAMIC VALUES FOR SIMULATED STORAGE TANKS

	Building 20040		Building 20050	
	Alt 1	Alt 2	Alt 1	Alt 2
Cooling capacity (KBTU's)	6000	4000	10000	6500
T _a (Ground temp) (°F)	63	63	63	63
T ₀ (°F)	44	44	44	44
U ₀ (BTU/Ft ² Hr°F)	.05	.05	.05	.05
T (°F)	44.053	44.060	44.045	44.052
A ₀ (Ft ²)	2326.77	1775.64	3271.08	2454.46
m (lb)	500,000	333,333	833,333	541,667
C _{po} (BTU/lb°F)	1.0	1.0	1.0	1.0

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